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I. BEER, SCIENTIFICALLY AND SOCIALLY CONSIDERED.

By James Samuelson, Editor.

During a visit which I paid last year to Germany, the Tyrol, and Switzerland, I was greatly struck with the fact that in countries where beer is the national beverage, the humbler classes are comparatively sober; whilst in those parts where wine, even the thin wine of the country, and ardent spirits usurp the place of the milder beverage, there is a nearer approximation to the habits of our own people—in other words, there is a large amount of drunkenness.

In publishing elsewhere a short account of my observations,* I ventured to express the opinion that the man who should succeed in introducing into Britain and bringing into general consumption a mild, brisk, sparkling beverage such as one gets abroad, would be a greater benefactor to his people than the most self-denying devoted advocate of teetotalism, and some of the most influential organs in the country, and notably three,† have more or less emphatically endorsed this view in their criticisms. What is still more satisfactory, I have received inquiries concerning the difference between the processes of manufacture of the English and German beer, from persons who have the will and ability to carry out my suggestion, whilst German beer is daily more sought after, and in our large towns, such as London, Manchester, and Liverpool, it may readily be procured, though the cost is rather high owing to the limited consumption. Instead, therefore, of having over-estimated the importance of the beer question, I find that it is far more deserving of consideration than I had imagined, and after having directed my attention to it, and inquired further into its scientific and social aspects, I have arrived at the conclusion that there are few subjects of greater national importance to us as Englishmen.

One of the journals to which reference has been made,‡ has gone so far as to say that "wholesome beer and wholesome recreation

* 'The German Working Man.' Longmans.

† 'The Illustrated London News,' January 1; 'The Pall Mall Gazette,' January 8; 'The Gardener's Chronicle,' March 19.

‡ 'The Pall Mall Gazette.'

Tunnery at Messrs. Allsopp & Sons' Brewery, Burton-on-Trent.

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are, for the most part, beyond the reach of our working men;" and although much of the blame rests with the operatives themselves, who prefer to give 6*d.* per quart for bad beer at a public-house, rather than the same price for the finest Burton ale, which they could easily procure by combination, yet it is perfectly true that a large proportion of the beer now sold to the masses is totally unfit for consumption. If any of my readers are disposed to doubt this, let them read the following paragraph which I have extracted from the proceedings of the Liverpool Select Vestry, as reported in the Liverpool 'Daily Post' of January last:—

"POISONOUS BEER AND LUNACY: A BREWER'S TESTIMONY."

"A conversation as to the cost of pauper lunatics arose, and Mr. Glover, addressing the committee, said he thought that, with regard to lunacy, they began at the wrong end. He had visited the lunatic asylums in Lancashire within the last three or four months, and he had asked the masters of the institutions what was the cause of the increase in pauper lunatics? The answer was drunkenness, and he (Mr. Glover) believed that that was the case. He thought the health committee ought to be asked to appoint some sort of an inspector to look after the quality of the drink sold. They appointed inspectors of meat and fish, and they condemned bad fruit, but bad drink was ten times worse than all of them. There was a law which, if put in force, punished people for using poisonous ingredients in the making of beer—preventing them from using grains of paradise, nux-vomica, oil of vitriol, ammonia, and other things that were used in making beer. That was in addition to malt and hops, but if only malt and hops were used there would be no lunatics from drink. His impression was that all a working man could spend in honestly brewed beer would not kill him or drive him mad, if the beer were good. There were some dishonest publicans as well as dishonest brewers; and there were some publicans who rode handsome chargers, and their wives were driven about in splendid equipages, and they were doing great injury to people and filling the workhouses. He believed the drink they sold was not honest drink, but contained some of the things he had described. When a brewer had beer that would not keep long, he said to his customer, when it got a little sour, that he would change it. It was taken back to the brewery when sour, and then the dishonest publican bought it for 10*s.* or 1*l.* a barrel. He then went to the druggist's shop, and got something that neutralized the acid; and, was not the poor creature who afterwards drank the beer likely to go mad? If a man had a pint or two of good honest beer, he would never go mad. The health committee ought to attend to the matter, and see that good beer was given to the people."

We shall presently have an opportunity to consider scientifically the character of those precious ingredients, grains of paradise, *cocculus indicus*, and other substances not mentioned by the candid brewer whose remarks I have just quoted, with which the poor man's beer is drugged; but before doing so, I propose to give a short account of the materials which ought to be used in the production of wholesome beer, of the scientific principles involved in the art of brewing, and of the most approved methods adopted at respectable breweries at home and abroad.

It would occupy too much space to enter fully into the history of beer, but it may interest some of my readers to know that its use is well authenticated in the days of ancient Rome, and according to Tacitus, the old Teutons had already acquired that taste for "Lager," which has been transmitted to their descendants in our time, for that author mentions it as their common drink. Pliny, too, states that it was consumed in Spain and Gaul, and that it was made from various kinds of grain, whilst a recent writer on the history of Burton-on-Trent,* tells us that the brewing of ale in that town is unquestionably coeval with the Abbey, it being a beverage of much repute with the Saxons, so that there can be little doubt of its having been drunk all over Europe in very early times. Mr. Molyneux, the author referred to, tells us, however, that the brewing *trade* of Burton-on-Trent is comparatively recent, and the credit of having originated it is accorded to one Benjamin Printon who lived in the early part of the last century, whilst at the close of that century there seem to have been only nine brewers in Burton, amongst whom appear the names of Bass and Worthington, but not yet that of Allsopp, whose ancestor, Mr. Benjamin Wilson, was however doing a large business in 1748.† Such of my readers as are curious on these matters, will do well to peruse Mr. Molyneux's interesting little treatise, where they will also find a variety of information concerning the geology, &c., of the Burton district: but we must now proceed to consider the materials which enter into the manufacture of beer.

Those are, or should be, water, malt (barley), hops, and yeast, and these substances possess not only a practical value for the brewer, but many special points of interest for the chemist and the student of botany. There has long been, to the uninitiated, a mystery connected with the water of Burton-on-Trent, the prevalent notion being that it is the river water which possesses some special virtue for brewing purposes. The fact is, however, that it is the spring-water of the district which is so well adapted for the manufacture of beer, and, although the effect is not yet clearly understood,

* 'Burton-on-Trent; its History, its Waters, and its Breweries.' By William Molyneux, F.G.S. Trübner and Co.

† 'Burton and its Bitter Beer.' By Dr. Bushnan. W. S. Orr and Co.

the cause has long been well known to chemists. It arises from the presence in the water of "earthy sulphates and carbonates," and the absence of organic matter which is fatal to the brewing process. Analysis has shown the Burton water to contain nearly 19 grains of sulphate and 15 grains of carbonate of lime to the imperial gallon (besides sulphates of potassa and magnesia), and the theory is that these alkalies combine with the acid of the malt extract, and, in the form of insoluble salts, are precipitated and carry down with them the nitrogenous substances which it is desirable to get rid of in the brewing process; so, for the same reason that the presence of salts of lime and potash in the Burton water is advantageous, that of organic matter would be injurious, and the freedom of the water from the latter is therefore very advantageous to the brewer. Should any of my readers desire further information on this subject for practical purposes, they may obtain it in the able article on "Beer," in Dr. Muspratt's 'Dictionary of Chemistry,' or in those on the same subject in Ure's 'Dictionary of Arts,' and Watts's 'Dictionary of Chemistry;' while Mr. Molyneux's work, already named, also contains an excellent chapter on the "Waters of Burton," and the effect upon them of the strata through which they percolate.

Malt, as every one knows, is barley steeped and dried. There are various kinds of malt, known as pale, amber, brown, and black, of which the first-named is employed in brewing pale ale, and the last (which is roasted like coffee) is used for colouring porter. Barley undergoes two kinds of change during its conversion into malt, the one morphological, that is to say, in its plant life, the other chemical. In order to effect the conversion it is steeped for two or three days in water, then spread out upon a floor to germinate, and when it has sprouted to a certain length it is taken to the kiln to dry, and in the subsequent handling "the radicles" which have shot forth during germination, are broken off and the grain assumes to a great extent its original appearance. The annexed woodcuts will render the morphological change apparent to the eye; Fig. 1 being a grain of barley with the husk removed to show the embryo; Figs. 2 and 3 the same after germination.*

FIGS.

1. 2. 3.

But a chemical change, not so easily understood, also takes place in the malting process, and I will endeavour in a few sentences to make it as clear as possible. For our purposes, the barley may

* These woodcuts, and some others in this article, have been copied, with the permission of the publishers, from the plates in a beautiful and interesting volume 'On Strong Drink and Tobacco Smoke,' by the late H. P. Prescott, F.L.S., just published by Messrs. Macmillan and Co. Frequent references will be made to this work. Mr. Prescott died recently of consumption, and his book has been passed through the press, and edited, with much good feeling, by Professor Huxley.

be said to be composed of two main constituents, albumen and starch, and during the germinating process the albumen is converted into a new substance, diastase, so called from its property of being able to split up the other constituent of the grain, starch, into dextrin or gum, and sugar. The object of this chemical change in *nature* is to supply the embryo of the plant with a soluble pabulum or nutriment; but as in malting the germination is arrested at an early stage, the starch is converted into soluble gum and sugar, merely to be extracted in the mashing process which follows at the brewery. The result of this extraction is to produce the "worts," or "wort," the stock, so to speak, of the beer.

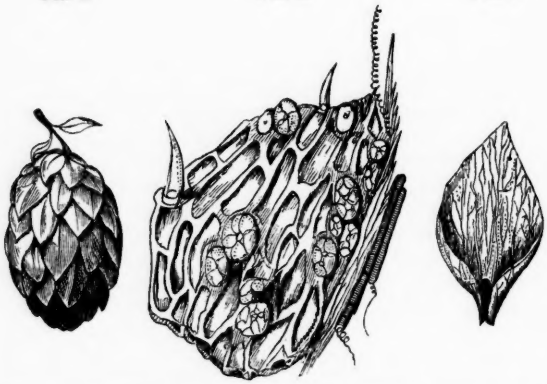
The morphological changes which take place in the growth of the barley, either during germination or subsequently, are deeply interesting, and an illustrated account of them will be found in Mr. Prescott's work referred to, whilst a detailed description of the chemical changes to which the grain is subject is contained in the various articles on "Beer" (more especially Dr. Muspratt's) in the Dictionaries already quoted. These are, however, beside our purpose, and we must now pass on to the other materials used in brewing, namely, hops and yeast, both of which are as interesting as malt to the chemist and botanist.

The hop-plant belongs to the same botanical group as the stinging nettle (*Urticaceæ*) and is cultivated chiefly in the counties of Kent, Sussex, Surrey, Worcester, and Hereford, and also imported from the Continent. The bitter principle which it contains, and which is extracted in the boiling process of the brewer, is called "*lupulite*," and it is found in the fruit, which is so well known as hardly to need description. For the guidance of my readers, however, I will extract a short account of it from Mr. Prescott's work, accompanied by such of the figures as seem essential:—

"The fruit of the plant," he says on p. 40, "(technically called *strobilæ*), which is so largely used in brewing, consists of a series of delicate green, semi-transparent bracts, attached to a common stalk (Fig. 4) and overlapping at their edges in a very elegant manner. The seeds are minute, flattened, conical berries of a light-brown colour; they are attached to the bases of the bracts (Fig. 5) which fold over at their lower edges to afford them additional support, and each inner seed-containing bract is covered by another externally. Attached to the outer seed-coat is a beautiful transparent membrane, and on this lie, in countless numbers, minute golden-coloured oval bodies which are the *lupulite* so valuable to the brewer (Fig. 6). These granules are abundant on the bracts, especially at their bases, where the seed is lodged; they are also present in large quantities on the leaves of the plant. When one of these granules is placed in water under the microscope, and a drop of sulphuric or nitric acid is added, it immediately bursts, and the

coloured matter discharged is seen to consist of excessively minute, somewhat spherical, particles of an oily nature, that move freely and

FIG. 4. FIG. 6. FIG. 5.



with great rapidity amongst each other with a tremulous motion. This peculiar motion may at times be observed in the contents of the granules before they are broken." * * * "A common practice amongst hop-buyers is to take a small quantity of the dried hop-fruit, place it in the palm of one hand, and with three or four knuckles of the other, to chafe and bruise it. The value of the sample is judged of by the aroma it emits and the sticky almost resinous stains left upon the hand. This is a rough but effective way of judging both of the number and produce of the *lupulite* granules by crushing them. Good sound hops will yield about one-sixth part of their weight of these grains. Analyzed by the chemist they are found to contain, besides a volatile oil, no fewer than thirteen substances, more or less in combination with each other. But it would appear that to the volatile oil, soluble in water and alcohol, and the bitter principle, *lupulite*, the most valuable properties of the fruit are due."

I have made this somewhat lengthy extract from Mr. Prescott's book for a twofold reason; first, because it conveys in brief and clear terms all that is interesting to us, in this portion of the subject, and secondly, because I consider that his powers of observation and his practical researches deserve to be prominently noticed. In another part of his book he tells us that he examined the spent hops of breweries and found that not more than one-half their *lupulite* is made available, a circumstance which shows how necessary it is to call into requisition, more largely, the services of scientific men, even in our most commonplace manufacturing processes.

Yeast is a lowly unicellar plant called *Torula cerevisiæ*. The growth of its cells (which on examination with the microscope are found to contain minute nuclei) has been ably described * by an eminent botanist (Dr. Henfry), who obtained some fresh wort in which fermentation had commenced and placed a drop of the liquid under the microscope. At first, he says, these globules enlarged until they attained a certain size, and then they remained unchanged for a time. Next, a little point-like bud was seen to project from one portion of the cell-wall, and this grew until it attained the same size as the parent cell. This occupied about three hours, and by a repetition of the process sixteen cells were developed from a single one. After a time the growth slackened and at length it ceased, the observer believed, "undoubtedly because all was removed from the liquid which could serve for their growth." The following woodcuts represent the microscopical appearance of the cells of the yeast fungus, Fig. 7 being that found at the bottom, and Fig. 8 a "white mealy substance," at the top of the liquid; the growing globules will be seen in the former, from which my microscopical readers will perceive that the plant multiplies by the well-known but incomplete process of fission.

Fig. 7.

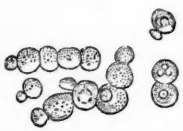


Fig. 8.

These, then, are the materials which should be employed in the brewing of good ale. Water, free from organic matter and containing sulphate and carbonate of lime; barley, in the form of malt; hops, and yeast; and although the reader will have gathered from the preceding short account of these substances, what leading principles are involved in their use and treatment, I propose briefly to recapitulate the changes which occur in the brewing process, before attempting to describe the practical operation. In the malting or germination of the barley the albumen in the grain becomes converted into diastase, the property of which is to change the *starch* (also constituent in the barley) into soluble dextrin or *gum*, and *sugar*, and consequently the malt possesses a sweet taste which is not present in the grain previous to malting. In the mashing process, this sweet substance is washed out of the malt, and with the water employed for the purpose goes to form the "*wort*," or stock of the beer. This "wort" is subsequently boiled with *hops*, which contain a bitter principle, *lupulite*, and an *essential oil*, of which the effect is to impart a bitter aromatic flavour to the beer, at the same time as the chief *organic* constituents of the *wort* are removed. And finally through the introduction of yeast, a minute

* 'Micrographic Dictionary' (article "Yeast-Plant"), from which, with the publisher's permission, the woodcuts are copied.

plant, the cells of which multiply with incredible rapidity, *fermentation* is set up, the chemical effect of which is to convert the *sugar* contained in the "wort," into *carbonic acid* and *alcohol*.

The brewer takes care, however, to stop the fermentation at a certain stage, so that a portion of the sugar may remain unconverted, and the chemical change is then completed in the cask or bottle, the carbonic acid being held in solution until the beer is drawn or otherwise exposed to atmospheric action. This gives to good beer its brisk sparkling appearance and puts a *head* upon it: in no case is the effect so conspicuous as in the *bottled* German beer and English and Scotch pale ales, which continue to effervesce and sparkle like champagne, long after the liquid is poured into a tumbler.

Passing now from the theory to the practice of brewing, I propose to conduct my readers through some portions of the magnificent establishment of Messrs. Allsopp and Sons, of Burton-on-Trent, where all that science and skill can accomplish has been done to perfect the process. Let us commence with the malting; and the reader must imagine himself in a large chamber (one of several devoted to this purpose), one end of which is partitioned off for the steeping process. This side of the room, which forms an elongated trough, is divided into squares, and partly floored with a number of perforated tiles, which serve to drain off the water; and when the barley is sufficiently steeped, it is turned out upon the chamber floor, close to the trough. Here it is kept within certain limits, by means of a removable partition consisting of boards, which can be fixed between the columns that run across the chamber parallel to the steeping-trough, or removed at pleasure; and the barley is then said to be in the "couch," where it is gauged by the Excise. After gauging, the partitions are removed and the steeped barley is spread evenly over the chamber floor to germinate: the germination having reached the proper stage (as already described), it is conveyed to the kiln to dry. But at Allsopps' the transfer of the barley from the germinating floor to the kiln is only the passage from one chamber to another immediately adjoining; and unless his attention is directed to the floor, the uninitiated visitor would observe nothing in this second chamber to denote its function. The floor is paved with perforated tiles, and in the kiln pit underneath, which is the same size as the upper chamber, there stand a series of open furnaces, or gigantic braziers, in which coke fires are lighted when the kiln is in use. Over the fires there is a contrivance called a disperser, by which the heat rising from these furnaces is equalized over the whole surface; and when the spectator looks up at this disperser, he perceives plainly the perforations in the tiles of the kiln floor above, and which allow the heat to penetrate to the malt. After kiln-drying, the barley, or as it is then called, malt, is subjected to one more process, namely, screening. This consists in allowing it to run over an ob-

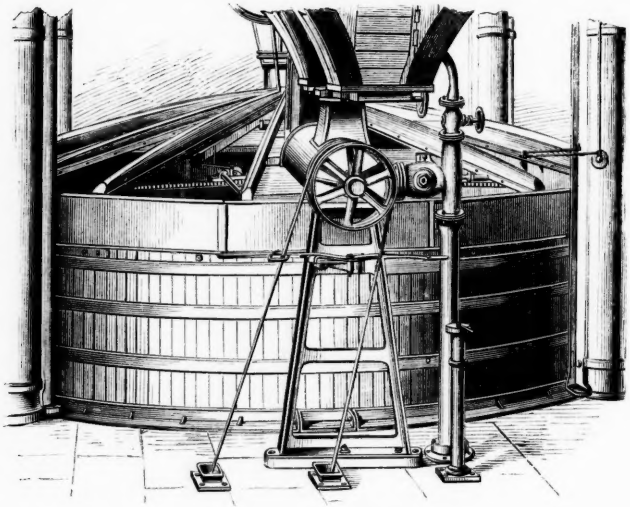


Fig. 1.—Mash Tun (Closed).

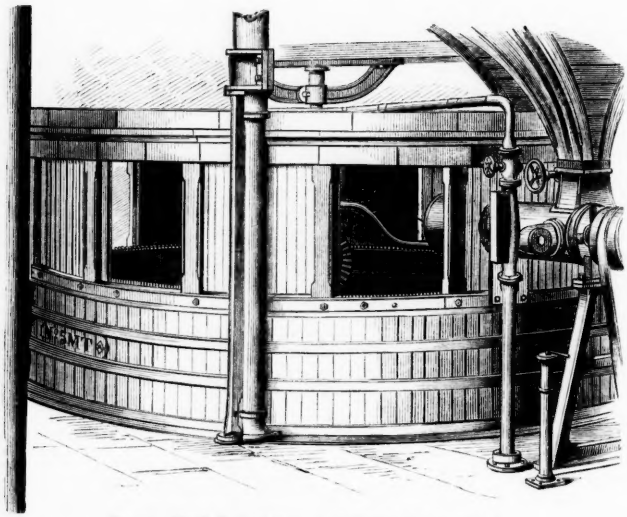
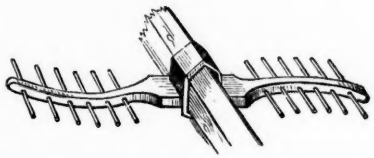


Fig. 2.—Mash Tun (Open—"showing the Sparge").

lique screen, and during its passage the malt dust and radicles are removed. These make an excellent food for cattle, varying in value from 5*l.* to 7*l.* per ton, according to the requirements of the season.

This completes the malting process; and now we pass on to the brewing, which commences with the *grinding of the malt.* By means of a "Jacob's ladder," it is conveyed to an upper story, and there allowed to fall into a hopper, which feeds a pair of smooth rollers, very similar to those used in an oil mill for rolling linseed. Being thus split, and partially ground, it is carried along the chamber floor by means of an Archimedian screw, and passed through a hole in the floor into a large hopper in the story below. This hopper is fixed above the "mash-tun," or "mash-tub," where the ground malt is mixed with water at a temperature of 170° to 180°, and undergoes the *mashing* process. The room in which we are now supposed to stand contains eight such tubs, each capable of treating fifty quarters of malt, and two of them are shown in Plate II., the one closed and the other open. I was, unfortunately, unable to obtain a sketch, which would fully illustrate the mashing process, but will endeavour to make it as clear as possible with the means at my command.* The mash-tun has a false bottom, composed of radiating sections, the object of this being to take them out to clean after each mashing. Then there revolve in the tub two kinds of apparatus, the one for "mashing," the other for "sparging," to be explained presently. An upright spindle revolves in the centre of the tun; and rotating with it, is a strong horizontal wooden pole, having one end affixed to the central spindle, and the other end, to which a cog-wheel is attached, resting upon rack-work that runs completely round the inside of the tun. The arrangement will be better understood if the reader pictures to himself one of those "roundabouts," on which children ride at fairs, with the horizontal pole resting on rack-work, which is visible in the plate. Along the rotating *horizontal* pole there are placed several beaters, somewhat resembling the rakes upon a reaping machine, but armed with teeth on either side. I have sketched (Fig. 9)

Fig. 9.



one of these beaters with a portion of the horizontal pole, and by a suitable mechanism the beaters are made to revolve *vertically* in the

* All the page plates are copied from photographs kindly lent me by the Messrs. Allsopp.

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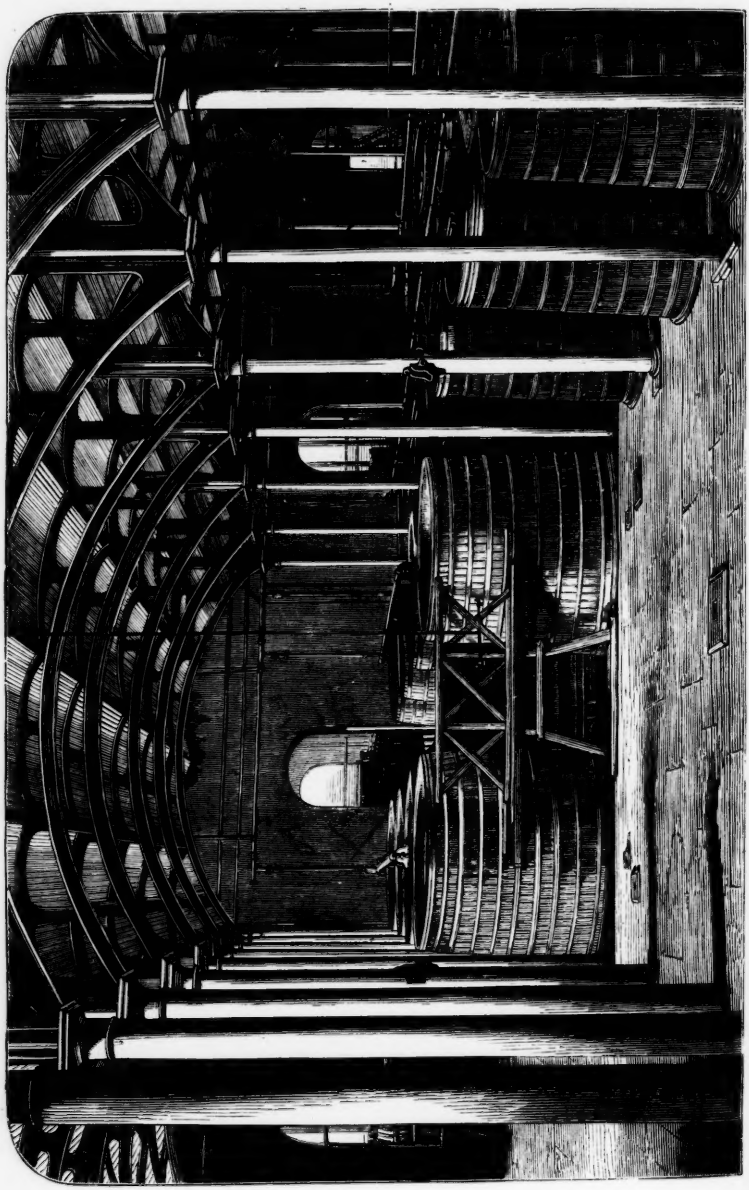
mash, whilst the pole to which they are attached rotates *horizontally*, so that the whole contents of the tun are thoroughly beaten and mixed. This operation has really a very novel and interesting appearance to one who has never witnessed it before. As the observer stands looking into one of the openings in the mash-tun, nothing appears to be going on in the mash so long as the beaters are on the side opposite to him, but presently a slight undulation of the surface announces their approach. Slowly the pole, with its beaters, moves round towards the side where the spectator stands; the undulations become more marked, until at length the revolving arms make their appearance, breaking up the surface and creating a great commotion. After the round is completed, the apparatus is stopped, and the mash is left undisturbed for some time, the process being repeated at regular intervals. But there is another rotating apparatus of a very simple kind attached to the central spindle, and that resembles in appearance and action the horizontal discharge-pipe at the back of a watering cart. It is in fact a copper pipe, of a suitable shape, with holes drilled along its whole length, and may be seen on looking through one of the openings in the mash-tun (see Plate II.). After the strongest portion of the "wort" is obtained from the malt by the mashing process already described, it is dosed with a shower of hot water, poured upon it from this rotating pipe, which is called the "sparge," the operation being termed "sparging." At the bottom of each mash-tun there are four pipes through which the wort is drawn off, and these pipes lead into a main which conducts the liquid into the "underback," an intermediate vessel between the mash-tun and the boiling copper, where, as the name indicates, the process of *boiling* with hops is carried on.

The boiler is an open copper cauldron or kettle, set in brick, and heated from beneath. It has a capacity of about seventy barrels; and when the requisite quantity of hops is deposited in it, the wort is admitted through a pipe connected with the "underback," into which the liquor has been run from the mash-tun, as already described. The feed-pipe bends over the opening of the copper, whilst at the bottom of the same vessel is another pipe, through which, when the boiling is complete (and the liquor is well stirred during the process), the boiled wort, or unfermented beer, is run off into the "*hop-backs*." These, again, are intermediate vessels, square wooden cisterns, with false bottoms, which act as a sieve, and the object of running the liquor into them is to free it from the spent hops with which it is accompanied, before cooling and fermentation.

A word concerning the spent hops. After the liquor has been allowed to drain from them in the hop-backs, they are placed in hydraulic presses to extract any wort that may still remain in them, and are then packed and sold as manure.

From the "hop-backs" the wort runs into the *refrigerators*,



Fermenting Room at Messrs. Allsopp's Brewery.

of which there are two or three descriptions, some of them occupying the floors of enormous chambers, which are moreover open to the external atmosphere through the peculiar construction of the windows. The principle of these refrigerators is, however, always the same, the hot wort being allowed to flow over a series of tubes through which cold water freely circulates. Sometimes the tubes form a spiral coil, at others they run in parallel rows, covering the entire floor of the chamber, but in every case they slope in an inclined plane, so that when the wort is poured on at the higher end it flows down slowly to the lower, becoming cooled in its passage. In winter the cold air, which is admitted on all sides into the cooling chamber, suffices to reduce the temperature of the wort in its passage down the inclined plane, but in summer it is necessary that the water which flows through the pipes should be made as cold as possible; and at Messrs. Allsopp's, water is cooled on a large scale for this purpose by the evaporation of ether. This is done outside of the main building, and the water thus cooled is conducted all over the brewery, not only into the wort-refrigerators, but wherever a low temperature is found requisite in the brewing process.

From the coolers the wort is next conveyed into the "fermenting rounds," capacious vessels, each holding from 15 to 90 barrels, and an idea may be formed of the magnitude of the operations carried on at Allsopps', when it is mentioned that the new brewery (there are two) has two fermenting rooms, each containing 136 such vessels, consequently above 4000 barrels of beer may be fermented at one time. Plate III. represents a portion of one of these fermenting chambers. The principle involved in *fermentation* has already been described, as the conversion of the saccharine matter in the wort into carbonic acid and alcohol. As my readers are no doubt well aware, it is effected by adding to the wort a quantity of fresh yeast from a previous brewing, and such an amount of carbonic acid gas is generated that the invisible gas occupies the whole space between the surface of the fermenting liquor and the rim of the vessel. A very curious effect shown to visitors is to pass a hat through the apparently empty space over the liquor in the fermenting vessel. This hat at once fills with the invisible gas, which may then be poured into another belonging to a visitor, just as we see chemical lecturers illustrate the specific gravity of the carbonic acid gas they have been making, by pouring it from one glass vessel to another.

Let me, in passing, refer to the method in which, at Messrs. Allsopp's, the superfluous yeast is utilized, for it is only at these large establishments that every waste product is turned to good account. First, as much of the ale as possible is allowed to drain from the yeast, and then it is press-packed. The soft yeast is placed between suitable cloths and transferred to hydraulic presses

of low power, which reduce it to pretty much the same consistency as the imported Dutch yeast. In this condition it is packed and exported to France for distilling purposes.

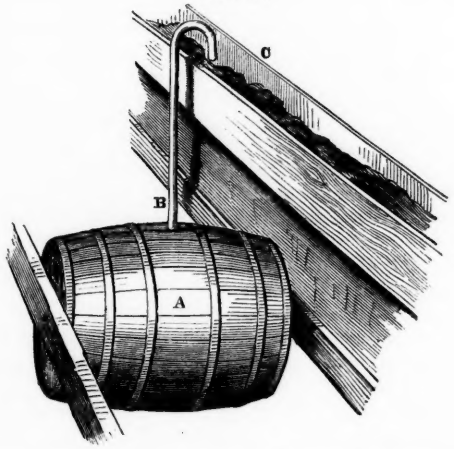
The rationale of the fermenting process is not as yet thoroughly understood, but it is known that the surface yeast is formed by the nitrogenous matter contained in the wort being carried upwards by the bubbles of the generated carbonic acid gas. When this fermentation is carried on at a temperature of from 65° to 90° Fahrenheit, as it is almost always in England, the yeast invariably rises, and in Germany this is called "Obergährung," or top-fermentation; but in Bavaria and elsewhere abroad, the fermenting process is often carried on at a lower temperature, and then it is called "Untergährung," or "bottom fermentation," for in that case the yeast does not rise, but the nitrogenous matter sinks to the bottom and forms a slimy sediment. This is the essential difference between the Continental and English methods of brewing; except perhaps that abroad a larger portion of saccharine matter is left in the beer, which, under a cool temperature is gradually converted into carbonic acid and alcohol in the vessels into which it is subsequently conducted or poured, and the result is a rich effervescing beverage. I am indebted to my friend Mr. Fenton, the Secretary of our Embassy at Munich, for some interesting particulars concerning the method of brewing in that city. "Obergährung," or "top-fermentation," is there conducted at 15° to 17° Reaumur = 66° to 71° Fahrenheit, and "Untergährung," or bottom fermentation, at 12° R. = 59° F. The process is not carried on as with us on the floors of the brewery, but in specially constructed subterranean chambers ("Gährkammer") in which the temperature is kept low by means of ice, and thence the beer is conducted by pipes into the vessels in which the fermentation is completed.*

In England, as abroad, in the best breweries, the beer is conducted after fermentation into barrels specially constructed for the purpose, in which the fermenting process is completed. This at Allsopps' and other large breweries is called the "Union" system, long rows of barrels being connected together by a horizontal pipe. The barrels are raised above the floor, suspended in a frame, and are made to revolve on their axis precisely the same as a revolving barrel-churn. The chamber in which they are placed is called the "Union-room," or tunnery, and the reader will form a fair idea of its extent and appearance by referring to the Plate (I.). There are two rows of barrels as shown in the

* The German system of mashing is also entirely different from the English. I believe that the best book published abroad on the Continental system of brewing is 'Die Bierbrauerei,' by Heiss, published at Augsburg, 5th edition, 1869, price 5 florins; but I was unable to procure it in time for the preparation of this essay.

Plate, and above and between the rows runs a long tank, in which the superfluous yeast is collected. This is done by means of a "swan-neck" pipe, a syphon acting inversely, and the arrangement will be understood from the following woodcut (Fig. 10), where A

FIG. 10.



is one of the barrels containing the incompletely fermented beer, B the swan-neck, C a portion of the long tank or receptacle for the yeast (Fig. 10). The latter continues to rise slowly whilst the beer remains in the barrel, being carried upwards (as during active fermentation) by the escaping carbonic acid gas, and having risen into the "swan-neck," it may be seen slowly bubbling over into the tank. The temperature of the beer during this process is regulated by a flow of water through an ingeniously contrived tubular apparatus, which can be inserted into or withdrawn at pleasure from the barrel, through an oblong aperture in front (see Fig. 10); and when the beer is cleared of the remaining impurities it is drawn off by boys who creep underneath the barrels and open a tap attached to a pipe, first into large vats and then into casks for sale. The object of allowing the barrels in which fermentation is completed to revolve, is simply that they may be cleansed after each operation.

It has, of course, been impossible for me within the short limits of an essay, professing to deal with the social as well as the scientific aspects of this question, to describe fully either the principles or practice of brewing; but I hope enough has been said to convey to the reader a fair idea of both; and there now remain to be con-

sidered: 1st, how beer is injuriously affected during or subsequent to its manufacture; and 2nd, what social results follow from its adulteration or abuse. Those who have mixed much with artisans know well that they seldom drink the fine Burton ale, and if they do, it is often adulterated after it leaves the brewery; but with a view to ascertain what they really do drink, I have obtained from my friend Mr. Norman Tate, F.C.S., Analytical Chemist of Liverpool, who has interested himself deeply in this question, a report upon the Liverpool beer, which is as follows:—

"The results of the examination of twenty-five samples of beer of the kinds known as 'sixpenny,' and 'eightpenny,' purchased in the ordinary way from public-houses in different parts of Liverpool, showed that the quantity of alcohol varied in these samples from 2·2 per cent. (by weight) to 5·62 per cent., the percentage in fourteen specimens being under 4, very little difference being observable in this respect between the sixpenny and eightpenny. The general results convinced me that fully half the samples were not genuine preparations of malt and hops. One undoubtedly contained *tobacco;* another, of a dark colour and rather hard unpleasant taste, gave unmistakable evidence of the presence of *sulphate of iron;* whilst two others contained such a quantity of *common salt* as could not be accounted for by the presence of that ingredient in the water used for brewing, or by any other ordinary cause. *Sugar* also appeared to have been added in one case, and in another *carbonate of soda.* I did not find in any of these specimens indications of *cocculus indicus*, or picric acid, said to be frequently used for adulterating beer (I have found picrotoxin, the active principle of *cocculus indicus* on a previous occasion), but that other matters, such as liquorice, gentian, and other drugs, not of an injurious character, but nevertheless adulterants, were present I have not the least doubt. Several of the samples were of an objectionable character owing to bad brewing or bad keeping, and, in one or two instances, the quality was so bad that it is difficult to imagine how any persons can be found to drink such vile stuff. Only eleven out of the twenty-five were of what I consider really good quality. One of these was a sample which I purposely obtained, knowing it to be brewed by a leading firm at Burton, and to have been kept with great care by the person from whom I procured it.

"With regard to bitter beers I obtained somewhat better results, so far as general quality is concerned, with the exception, however, that the use of other bitters than hops seemed to be rather the rule than the exception. Although it is difficult or even impossible always to detect these bitters by distinct chemical tests, yet my experience of such drugs has made me so familiar with their taste that I have no hesitation in saying that quassia, wormwood, gentian, rue, camomile, and orange-peel had been used. Quassia

and wormwood, however, seemed to me to be the bitters in most general use, the quantity of the latter in one case being so great as to make the beer positively nauseous. One sample, which appeared to me to be flavoured with orange-peel, possessed a warm, somewhat spicy taste, which was very apparent in the residue after evaporation, indicating the addition of something more than the ordinary ingredients."

This report, it will be seen, affords experimental confirmation of what was said by Mr. Glover at the Liverpool Workhouse meeting, and it will therefore be interesting to inquire a little further into the matter. Our authorities tell us that the following substances are employed to adulterate beer. "*Cocculus indicus multum* (an extract of *cocculus indicus*), colouring, honey, hartshorn-shavings, Spanish juice, orange-powder, ginger, grains of paradise, quassia, liquorice, carraway seeds, copperas, capsicum, mixed drugs." These, we are told, "were seized at different breweries in London, and at brewers' druggists' laboratories."* In addition, sulphuric acid, alum, salt, *Datura stramonium*, picric acid, and other substances are mentioned by different writers.

Of *Datura stramonium* Mr. Prescott says,† "It has been frequently used by desperate characters for hocussing or stupefying the intended victim of a robbery by surreptitiously adding it to his beer at the public-house bar. It is the seed of the Thorn-apple, a native of Greece, and belongs to the same family as the tobacco-plant." The same author also describes very minutely the microscopical structure of the various seeds which ought, and which ought not, to be used in the preparation of beer, including barley, hops, *cocculus indicus*, grains of paradise, and *Datura stramonium*, his object being to facilitate the detection of fraud and crime; and I would recommend my microscopical readers, who take an interest in the question, to examine these various substances with the aid of a microscope and Mr. Prescott's beautiful diagrams.

Of the various adulterants named, sulphate of iron, alum, and salt are employed to give beer a "head" or froth (salt to stimulate the thirst as well); sulphuric acid is used to "bring it forward," or harden it, and impart to new beer the character of old; carbonate of soda to neutralize acidity; whilst *cocculus indicus*, quassia, wormwood, grains of paradise, and similar substances are mixed with beer either to impart bitterness or pungency, and to disguise the true character of the drink.

The necessity for all this doctoring has already been touched upon, but it may be as well to explain its cause more fully. At Allsopps' and other large Burton breweries (and no doubt in many

* 'Report of Committee of the House of Commons.' See Watts's 'Dictionary of Chemistry,' vol. i., p. 537.

† 'Strong Drink and Tobacco Smoke,' p. 37.

smaller respectable country breweries) the capital embarked in the trade is large enough to admit of the beer being perfectly fermented and freed from impurities or substances likely to cause acetification; the beautiful system employed by Messrs. Allsopp for that purpose has been described. But many brewers really sell their beer, not at the brewery, but in their own public-houses, and they have not sufficient capital (or it may be they are too anxious to make money) to give their products sufficient time to become fit for consumption. The beer is sometimes drawn off from the fermenting vats into the barrels in which it is to be sent out, with the bung holes open for the escape of superfluous yeast; as little time as possible is given for it to "fine," and it is sent out to the public-house with orders to return any that is unconsumed when it begins to turn sour. I do not pretend to be initiated into the mysteries of "brewers' druggists' laboratories," nor the secrets of those who employ their fraudulent compounds; but certain it is, that carbonate of soda is used to neutralize the acidity of the spoiled beer, and various drugs and chemicals are then added to impart to it an artificial flavour and counteract the alkaline taste, until, as Mr. Tate remarks, it is "difficult to imagine how any persons can be found to drink such vile stuff." But when we remember that three-fourths of the persons who do drink it are drunk already, the mystery is solved. Not only are the lower kinds of beer thus doctored, but they are often mixed with Allsopps', Bass's, and other fine ales, so that it is the interest of those firms not only to suppress adulteration, but to do their best to assist in providing the humbler classes with a cheap pure beverage, which it will not pay the vendors to sophisticate.

So far, repressive legislation has been a dead letter; we hear now and then of the Act of Victoria 23 & 24, c. 84, being put in force to prevent the sale of grossly adulterated food, or tea, but although brewers will tell us that the Excise would punish adulteration severely, I do not recollect ever having noticed a prosecution. Public analysts may be appointed under this Act, and it is to be hoped that the time is not far distant when this course will be adopted, and the doctoring of what is really the staple beverage of our people may be reduced to a minimum, if not entirely prevented.

But we have another question to consider in connection with the effects of beer upon our population, and that is its real or reputed strength. For this purpose I have compiled the following table, partly from the Dictionary articles referred to, and partly from analyses made for me by chemical friends.

A glance at this table and a moment's reflection will show why English beer-drinkers are so often drunkards, whilst Germans, who indulge in a similar beverage to the same extent, are comparatively sober. It may be safely said that the percentage of alcohol in German

beer is on the average half as great as in the English, so that where an Englishman drinks a pint, a German may partake of a quart; but when we look at the character of the beer drunk by the intemperate classes in England, and compare it with that of the poorer people abroad, we may unhesitatingly assert that less injury

Name of Beer.	Percentage of			
	Alcohol.	Malt Extract.	Carbonic Acid.	Water.
Strong Scotch Ale	8·5	10·9	0·15	80·45
Burton Ale	5·9	14·5	..	79·6
Barclay's London Porter	5·4	6·0	0·16	88·44
Dreher's Vienna Beer*	4·62	..	..	..
Low Brussels Beer (Faro)	4·9	2·9	0·2	92·0
Bavarian Draught Beer	3·8	5·8	0·14	90·26
Sweet Bohemian Beer (Prague) ..	3·9	10·9	..	85·2
Liverpool Doctored Beer (Mr. Tate's test)	2·2	..	..	..
Berlin White Beer	1·9	5·7	0·6	91·8
Sweet Brunswick Beer (Mum)	1·9	45·0	..	53·1

would arise from drinking half-a-gallon of German beer than from a pint of English ale. And again, when we compare the Berlin "Weissbier," which contains 1·9 per cent. of alcohol, with the lowest Liverpool beer, which Mr. Tate found to contain only 2·2 per cent., and consider that whilst the Prussian artisan may imbibe his beverage all day long from quart tankards with impunity, an English labourer will succumb to a few glasses of the public-house trash; what other inference can be drawn, than that it is not the beer but the drugs it contains which affect the brain? I have been told that English labourers will not take kindly to German beer; it is not strong enough for them. This is quite true of the present generation; how should it be otherwise, when their taste has been corrupted by *cocculus indicus*, tobacco, and salt? But unless the advocates of temperance strenuously support the introduction of a mild, pure, cheap drink (for the Englishman not alone buys bad beer, but pays three or four, aye in some cases five or six times as much for it as the German does for his unadulterated beverage), unless, I say, a vigorous effort is made to change the taste of the next generation as it grows up, the same difficulty will still remain to be overcome by posterity.

And now let me, in conclusion, refer to the data which have been given by an eminent Swiss social economist, to show (as I have done elsewhere†) that comparative sobriety is the result of

* For this test, I am indebted, through the kindness of Dr. Frankland, to Mr. W. Valentin, of the Royal College of Chemistry.

† 'The German Working Man,' p. 70, quoting Gustave Moynier, 'Les Institutions ouvrières de la Suisse. Cherbuliez: Paris.

the introduction of beer, and the displacement of stronger drinks. The canton of Soleure in Switzerland was formerly very intemperate, now it is much improved. This is partly attributable to the opening of small shops where *good* coffee (a thing unknown to the poorer classes in England) along with small white rolls and butter are sold; but concurrently with that, a change has taken place in the alcoholic drinks of the people, which is represented by the following figures, denoting a Swiss measure of 1½ litre:—

Consumed in	Swiss Wines.	Foreign Wines.	Beer and Cider.	Brandy.
1863 ..	1,334,865 ..	637,166 ..	23,168 ..	126,443
1865 ..	1,483,546 ..	953,944 ..	84,972 ..	121,120

The total consumption of alcoholic liquor, therefore, had increased altogether nearly 30 per cent., but the beer consumed was augmented threefold, whilst brandy had fallen off 4 per cent.!

Couple this experience with the fact that the Germans drink certainly as much, if not more beer than we do, and are sober, whilst we are perhaps the most drunken nation on the earth, and I conceive no one will dispute the proposition so often advanced by me, that as claret and light Continental wines are slowly reforming our middle classes, so will it be necessary to introduce mild, pure beer as a staple drink, in order to attain the same end amongst the labouring population. Until that is done, I am convinced that not all the efforts of temperance advocates (whose self-denial every one must admire and respect), neither lectures, tea-meetings, denunciation, nor repressive legislation, will avail anything beyond saving here and there a drowning wretch from the flood of poisoned liquor with which our large towns are deluged, but such a change as I have suggested being accomplished, I believe that, with the spread of education, and the introduction of more rational amusements than those now offered to the humbler classes, repressive legislation will be no longer needed; the ranks of our criminals, paupers, and lunatics will be thinned, and it is to be hoped the foulest blot will in time be removed from our national escutcheon.

II. SPIRITUALISM VIEWED BY THE LIGHT OF MODERN SCIENCE.

By William Crookes, F.R.S., &c.

Some weeks ago the fact that I was engaged in investigating Spiritualism, so called, was announced in a contemporary;* and in consequence of the many communications I have since received, I think it desirable to say a little concerning the investigation which I have commenced. Views or opinions I cannot be said to possess

* The 'Athenæum.'

on a subject which I do not pretend to understand. I consider it the duty of scientific men who have learnt exact modes of working, to examine phenomena which attract the attention of the public, in order to confirm their genuineness, or to explain if possible the delusions of the honest and to expose the tricks of deceivers. But I think it a pity that any public announcement of a man's investigation should be made until he has shown himself willing to speak out.

A man may be a true scientific man, and yet agree with Prof. De Morgan when he says,—"I have both seen and heard, in a manner which would make unbelief impossible, things called spiritual, which cannot be taken by a rational being to be capable of explanation by imposture, coincidence, or mistake. So far I feel the ground firm under me; but when it comes to what is the cause of these phenomena, I find I cannot adopt any explanation which has yet been suggested. . . . The physical explanations which I have seen are easy, but miserably insufficient. The spiritual hypothesis is sufficient, but ponderously difficult."

Regarding the sufficiency of the explanation I am not able to speak. That certain physical phenomena, such as the movement of material substances, and the production of sounds resembling electric discharges, occur under circumstances in which they cannot be explained by any physical law at present known, is a fact of which I am as certain as I am of the most elementary fact in chemistry. My whole scientific education has been one long lesson in exactness of observation, and I wish it to be distinctly understood that this firm conviction is the result of most careful investigation. But I cannot, at present, hazard even the most vague hypothesis as to the cause of the phenomena. Hitherto I have seen nothing to convince me of the truth of the "spiritual" theory. In such an inquiry the intellect demands that the spiritual proof must be absolutely incapable of being explained away; it must be so strikingly and convincingly true that we cannot, dare not deny it.

Faraday says, "Before we proceed to consider any question involving physical principles, we should set out with clear ideas of the naturally possible and impossible." But this appears like reasoning in a circle: we are to investigate nothing till we know it to be *possible*, whilst we cannot say what is *impossible*, outside pure mathematics, till we know everything.

In the present case I prefer to enter upon the inquiry with no preconceived notions whatever as to what can or cannot be, but with all my senses alert and ready to convey information to the brain; believing, as I do, that we have by no means exhausted all human knowledge, or fathomed the depths of all the physical forces, and remembering that the great philosopher already quoted said, in reference to some speculations on the gravitating force,

"Nothing is too wonderful to be true, if it be consistent with the laws of nature; and in such things as these, experiment is the best test of such consistency."

The modes of reasoning of scientific men appear to be generally misunderstood by spiritualists with whom I have conversed, and the reluctance of the trained scientific mind to investigate this subject is frequently ascribed to unworthy motives. I think, therefore, it will be of service if I here illustrate the modes of thought current amongst those who investigate science, and say what kind of experimental proof science has a right to demand before admitting a new department of knowledge into her ranks. We must not mix up the exact and the inexact. The supremacy of accuracy must be absolute.

The first requisite is to be sure of facts; then to ascertain conditions; next, laws. Accuracy and knowledge of detail stand foremost amongst the great aims of modern scientific men. No observations are of much use to the student of science unless they are truthful, and made under test conditions; and here I find the great mass of spiritualistic evidence to fail. In a subject which, perhaps, more than any other, lends itself to trickery and deception, the precautions against fraud appear to have been, in most cases, totally insufficient, owing, it would seem, to an erroneous idea that to ask for such safeguards was to imply a suspicion of the honesty of some one present. We may use our own unaided senses, but when we ask for instrumental means to increase their sharpness, certainty, and trustworthiness under circumstances of excitement and difficulty, and when one's natural senses are liable to be thrown off their balance, offence is taken.

In the countless number of recorded observations I have read, there appear to be few instances of meetings held for the express purpose of getting the phenomena under test conditions, in the presence of persons properly qualified by scientific training to weigh and adjust the value of the evidence which might present itself. The only good series of test experiments I have met with were tried by the Count de Gasparin, and he, whilst admitting the genuineness of the phenomena, came to the conclusion that they were not due to supernatural agency.

The pseudo-scientific spiritualist professes to know everything: no calculations trouble his serenity, no hard experiments, no long laborious readings; no weary attempts to make clear in words that which has rejoiced the heart and elevated the mind. He talks glibly of all sciences and arts, overwhelming the inquirer with terms like "electro-biologize," "psychologize," "animal magnetism," &c. —a mere play upon words, showing ignorance rather than understanding. Popular science such as this is little able to guide discovery rushing onwards to an unknown future; and the real workers

of science must be extremely careful not to allow the reins to get into unfit and incompetent hands.

In investigations which so completely baffle the ordinary observer, the thorough scientific man has a great advantage. He has followed science from the beginning through a long line of learning, and he knows, therefore, in what direction it is leading; he knows that there are dangers on one side, uncertainties on another, and almost absolute certainty on a third: he sees to a certain extent in advance. But, where every step is towards the marvellous and unexpected, precautions and tests should be multiplied rather than diminished. Investigators must work; although their work may be very small in quantity if only compensation be made by its intrinsic excellence. But, even in this realm of marvels,—this wonder-land towards which scientific inquiry is sending out its pioneers,—can anything be more astonishing than the delicacy of the instrumental aids which the workers bring with them to supplement the observations of their natural senses?

The spiritualist tells of bodies weighing 50 or 100 lbs. being lifted up into the air without the intervention of any known force; but the scientific chemist is accustomed to use a balance which will render sensible a weight so small that it would take ten thousand of them to weigh one grain; he is, therefore, justified in asking that a power professing to be guided by intelligence, which will toss a heavy body up to the ceiling, shall also cause his delicately-poised balance to move under test conditions.

The spiritualist tells of tapping sounds which are produced in different parts of a room when two or more persons sit quietly round a table. The scientific experimenter is entitled to ask that these taps shall be produced on the stretched membrane of his phonautograph.

The spiritualist tells of rooms and houses being shaken, even to injury, by superhuman power. The man of science merely asks for a pendulum to be set vibrating when it is in a glass case and supported on solid masonry.

The spiritualist tells of heavy articles of furniture moving from one room to another without human agency. But the man of science has made instruments which will divide an inch into a million parts; and he is justified in doubting the accuracy of the former observations, if the same force is powerless to move the index of his instrument one poor degree.

The spiritualist tells of flowers with the fresh dew on them, of fruit, and living objects being carried through closed windows, and even solid brick-walls. The scientific investigator naturally asks that an additional weight (if it be only the 1000th part of a grain) be deposited on one pan of his balance when the case is locked. And the chemist asks for the 1000th of a grain of arsenic to be carried through the sides of a glass tube in which pure water is hermetically sealed.

The spiritualist tells of manifestations of power, which would be equivalent to many thousands of "foot-pounds," taking place without known agency. The man of science, believing firmly in the conservation of force and that it is never produced without a corresponding exhaustion of something to replace it, asks for some such exhibitions of power to be manifested in his laboratory, where he can weigh, measure, and submit it to proper tests.*

For these reasons and with these feelings I began an inquiry suggested to me by eminent men exercising great influence on the thought of the country. At first, like other men who thought little of the matter and saw little, I believed that the whole affair was a superstition, or at least an unexplained trick. Even at this moment I meet with cases which I cannot *prove* to be anything else ; and in some cases I am sure that it is a delusion of the senses.

I by no means promise to enter fully into this subject; it seems very difficult to obtain opportunities, and numerous failures certainly may dishearten anyone. The persons in whose presence these phenomena take place are few in number, and opportunities for experimenting with previously arranged apparatus are rarer still. I should feel it to be a great satisfaction if I could bring out light in any direction, and I may safely say that I care not in what direction. With this end in view, I appeal to any of my readers who may possess a key to these strange phenomena, to further the progress of the truth by assisting me in my investigations. That the subject has to do with strange physiological conditions is clear, and these in a sense may be called "spiritual" when they produce certain results in our minds. At present the phenomena I have observed baffle explanation ; so do the phenomena of thought, which are also spiritual, and which no philosopher has yet understood. No man however denies them.

The explanations given to me, both orally and in most of the books I have read, are shrouded in such an affected ponderosity of style, such an attempt at disguising poverty of ideas in grandiloquent language, that I feel it impossible, after driving off the frothy diluent, to discern a crystalline residue of meaning. I confess that the reasoning of some spiritualists would almost seem to justify Faraday's severe statement—that many dogs have the power of coming to much more logical conclusions. Their speculations utterly ignore all theories of force being only a form of molecular motion, and they speak of Force, Matter, and Spirit, as three distinct

* In justice to my subject, I must state that, on repeating these views to some of the leading "spiritualists" and most trustworthy "mediums" in England, they express perfect confidence in the success of the inquiry, if honestly carried out in the spirit here exemplified; and they have offered to assist me to the utmost of their ability, by placing their peculiar powers at my disposal. As far as I have proceeded, I may as well add that the preliminary tests have been satisfactory.

entities, each capable of existing without the others; although they sometimes admit that they are mutually convertible.

These spiritualists are certainly not much in advance of an alchemical writer, who says—

"I asked Philosophy how I should
Have of her the thing I would.
She answered me when I was able
To make the water malliable,
Or else the way if I could finde,
To mesure out a yard of winde;
Then shalt thou have thine own desire,
When thou canst weigh an ounce of Fire;
Unless that thou canst do these three,
Content thyselfe, thou get'st not me."

It has been my wish to show that science is gradually making its followers the representatives of care and accuracy. It is a fine quality that of uttering undeniable truth. Let, then, that position not be lowered, but let words suit facts with an accuracy equal to that with which the facts themselves can be ascertained; and in a subject encrusted with credulity and superstition, let it be shown that there *is* a class of facts to be found upon which reliance can be placed, so far, that we may be certain they will never change. In common affairs a mistake may have but a short life, but in the study of nature an imperfect observation may cause infinite trouble to thousands. The increased employment of scientific methods will promote exact observation and greater love of truth among inquirers, and will produce a race of observers who will drive the worthless residuum of spiritualism hence into the unknown limbo of magic and necromancy.

If spiritualists would but attend to the teachings of their own prophets, they would no longer have to complain of the hostile attitude of Science; for hear what Thomas L. Harris urges, in his 'Lyric of a Golden Age!'

"The nearer to the practical men keep—
The less they deal in vague and abstract things,
The less they deal in huge mysterious words—
The mightier is their power.

* * * *

The simplest peasant who observes a truth,
And from a fact deduces principle,
Adds solid treasure to the public wealth.
The theorist, who dreams a rainbow dream,
And calls hypothesis philosophy,
At best is but a paper financier,
Who palms his specious promises for gold.
Facts are the basis of philosophy;
Philosophy the harmony of facts
Seen in their right relation."

III. THE RATE OF GEOLOGICAL CHANGE.

By H. M. Jenkins, F.G.S., Secretary of the Royal Agricultural Society of England.

Public opinion on questions of theoretical geology grows slowly, and usually precedes the statement of important speculations. The progress of discovery leads up to the induction, which, after floating more or less hazily in the minds of geologists for a certain time, is at last enunciated piecemeal at irregular intervals by the more daring theorists. Finally the scattered fragments are collected and arranged, bound together by the idea which connects them, and placed on record as a complete whole. This last is the task which I propose to attempt in reference to the progress of public opinion on the subject at the head of this article.

But first, let me clear the way by a short summary of the ideas which prevail amongst English geologists, so far as they bear on this subject. The prominent feature of the favourite modern school of geology in England—Uniformitarianism—is the belief that the forces in operation at the surface of the earth in former times differed in no appreciable degree from those now in action. This article of faith is, however, commonly restricted to what, for convenience of expression, has been termed "Geological time"—a period which is entirely represented by the rocks found on the earth's surface, from the oldest to those now in course of formation. According to this school, *the rate of geological change* has been approximately equal throughout the vast period which has elapsed since the deposition of the oldest stratified rock. Local variations of this law would doubtless be admitted by even the most thorough advocate of Uniformity, but the broad general principle characteristic of the creed is equality in the rate of change throughout all geological time.

Catastrophism, which is the name usually given to the other great school of geologists, is distinguished broadly by the tenet that in past times the forces in operation at the surface of the globe were of far greater intensity than they are now, and that great physical changes were then produced by more or less violent cataclysms. Probably there are geologists who now-a-days reject the catastrophes, but still cling to the belief that modern forces are much less intense, and modern changes much less rapid and extensive, than those which occurred in former geological periods. Therefore, whichever view we take of this theory, it is clear that its advocates believe that *the rate of geological change* was greater in past times than it is now; and the inference appears fair that, according to this school, the rate of change has, on the whole, progressively diminished from the earliest down to modern times.

In his Anniversary Address to the Geological Society last year, Professor Huxley defined a "third phase of geological speculation, namely, Evolutionism." This doctrine, in the words of the author, "embraces all that is sound in both Catastrophism and Uniformitarianism, while it rejects the arbitrary assumptions of the one, and the, as arbitrary, limitations of the other." To my mind it cannot well be distinguished from ordinary Theoretical Geology, unfettered by the trammels of any school; but obviously, the Evolutionist is prepared to accept whatever theory on *the rate of geological change* can be shown to be consistent with those known facts which can fairly be quoted as evidence.

The title of this article is capable of more than one interpretation, and in its various meanings it has already been investigated by speculative geologists. The late Professor Edward Forbes, in his lecture before the Royal Institution, "On the Manifestation of Polarity in the Distribution of Organized Beings in Time,"* endeavoured to show that the rate of development of *generic* types reached its maximum intensity, firstly, during the earlier Palæozoic periods, and secondly, during the later Neozoic periods; that is to say, near the beginning and the end of the geological scale. Again, the rate of development was shown to be at its minimum during the later Palæozoic (Permian) and earlier Neozoic (Triassic) periods, from which contiguous zero-points the development of generic types was asserted to increase in both directions.† This relation Professor Forbes termed "Polarity," and he showed how in several of the great divisions of the animal kingdom, two of their groups appeared to exercise a kind of "reciprocity," as, for instance, our old friends the Palæozoic four-starred corals *versus* the Neozoic six-starred. But Professor Forbes was careful to make the reservation that "the numbers of species in a group or genus at any given epoch is to be excluded, not being an element in the discussion of the question, though apt to be introduced through mistake of the nature of the generalization attempted to be attained." Indeed, the relations of individuals, species, and genera were favourite subjects of speculation with this poetic and philosophical palæontologist; and the generalization we have just sketched was a sequel to some other inquiries, in recording which he defines a genus as "an abstraction—an idea—but an idea impressed on nature, and not arbitrarily dependent on man's conceptions."‡ Again, "a genus consists of more or fewer of these *manies resulting from one* [species] linked together, not *by a relationship of descent*, but *by*

* 'Notices of the Meetings of the Royal Institution,' vol. i., p. 428.

† This view may be correct; but at present, as at the time when it was advanced, we have only negative evidence in support of it; and it is still very possible that Permian and Triassic rocks, rich in generic types, may be discovered in some hitherto unexplored region of the earth.

‡ 'Notices,' &c., vol. i., p. 196.

an affinity dependent on a divine idea."* It is necessary to bear in mind these definitions of a genus in order to understand the author's generalization of "Polarity" in the "development of generic types," and to prevent confusion with other ideas which I shall attempt to elucidate in the following pages.

Before estimating the rate of geological change in successive epochs, we must clearly understand the means by which that rate is measured. Our geological chronology is divided into epochs of greater or less extent, distinguished and characterized by certain forms of animal and vegetable life, either peculiar to them, or preponderating in number and variety during their continuance. We can conceive that in a previously unexplored country, far away from any region whose geology is known, the explorer may meet with diverse geological formations, each formation being characterized by a sufficiently numerous and distinctive fauna. If formation A contains 1000 species, and is 10,000 feet thick, and formation B contains 5000 species, but is only 1000 feet thick, and if the range of zoological rank in the 5000 species is approximately the same as in the 1000 species, we should be justified in saying of formation A, that, in comparison with formation B,—

(1) It was deposited very quickly; or,

(2) During its deposition species changed very slowly.

Further investigation by our hypothetical explorer might possibly furnish him with evidence that, during the deposition of formation A, the conditions of climate and physical geography had remained more or less stationary, and that the strata were deposited slowly. On the other hand, formation B and its fossils might yield evidence of great changes in climate and physical geography, and of comparatively rapid deposition. Under these circumstances, he would be justified in the conclusion that, during the epoch represented by formation A, the *rate of geological change* was much less rapid than during the period represented by formation B.

This hypothetical contrast will assist the reader in appreciating the significance of the following synopsis of the Palæozoic and Mesozoic rocks and their fossils, and will enable him to estimate how far these epochs agree with those which we have supposed to be represented by formations A and B respectively.

Professor Phillips, in his Rede lecture, delivered before the University of Cambridge in 1860,† remarks that if we select among the marine classes of animals those which are represented in all the great periods of geology, count the number of species yet discovered in them in British strata, and refer them at present to only three great periods, we find that the Palæozoic rocks contain 2729 species,

* *Loc. cit.*

† Afterwards published under the title of 'Life on the Earth.' Macmillan. 1860. See pp. 59–62.

the Mesozoic 2170, and the Cainozoic 1222. "The absolute number of marine species appears thus to be greatest in the Palæozoic strata; but when the thickness of the deposits, which represents elapsed time, is taken into account, the variety of forms in a given thickness or given period of time is very much less." This conclusion he illustrates by the following Table:—

	Total Species in eight Classes.	Maximum Thickness.	Relative Number of Species to 1000 feet.
Cainozoic strata	1,222	2,240	545
Mesozoic strata	2,170	23,190	164*
Palæozoic strata	2,729	57,154	41†

And he again observes (p. 62), "Thus it appears certain that the *variety of life* estimated by the marine tribes existing in a given period is greater in the more recent periods."‡

* Should be 93. † Should be 47.

‡ The editor of this Journal (Mr. James Samuelson) has asked me whether I may not have overlooked the biological aspect of the case, and whether this may not be the result of the laws of selection in the lower forms of life varying from those in the higher forms, and the rate of change being perhaps more rapid in the latter; *e. g.* low molluscs or acalephs having predominated in earlier times, might go on multiplying for ages without material change, their conjugation being, like that of plants, regulated by the elements, whilst in the fishes and higher molluscs, sexual selection and destruction of each other would be very active and would produce rapid change of species. It appears to me that at least two powerful arguments may be advanced against this interpretation. First, geologically considered, the interpretation would be erroneous because we are contrasting the abundance and variety of life characteristic of the different great periods, and it cannot be said of any one great period that it is characterized, for instance, exclusively by low molluscs, nor of any other that it is characterized exclusively by higher orders of that class, as is shown in the following Table by Professor Phillips:—

	Zoophyta.	Echinodermata.	Crustacea.	Brachiopoda.	Monomyaria.	Dimyaria.	Gasteropoda.	Cephalopoda.	Total.
Cainozoic ..	27	41	15	8	63	394	662	12	1222
Messozoic ..	103	245	65	165	308	499	389	396	2170
Palæozoic ..	379	225	218	632	196	342	401	336	2729

Thus the Palæozoic rocks abound both in the highest and the lowest orders of the testaceous Mollusca, *viz.* the Cephalopoda and the Brachiopoda, while the Tertiary deposits are characterized by the intermediate groups of Gasteropoda and Lamellibranchiata. The oldest fishes are not regarded by the best authorities as of uniformly lower types than the most recent; and with regard to the power of sexual selection, the advantage is doubtless on the side of the Palæozoic and Mesozoic representatives of the modern Claspers. But the weightiest argument, to my mind, is to be derived from the improbability that sexual selection in such animals (for, owing to our imperfect record, we are necessarily compelled to deal almost exclusively with animals of no high zoological grade) was to any great extent the result of direct volition, or that sexual selection was the determining cause of change of species, although it no doubt was one means to that end. It appears to me far more probable that changes in species have been rapid

These quotations show that so keen an observer and so thoughtful a philosopher as Professor Phillips had not allowed this subject to escape him; but I am not aware that any other geologist has discussed it from precisely the same point of view. The figures given by Professor Phillips show that the rate of geological change, with regard to the *relation between the deposition of strata and the changes in faunæ*, was neither uniform throughout all geological times, as the Uniformitarians would have it, nor more intense in the earlier periods, as the Catastrophists contend. On the contrary, these figures prove, to the extent which they go, that the rate of change was marvellously more rapid in the more recent periods, and that the increase in rapidity was rapidly progressive, from the earliest to the latest times. There are four times as many species* belonging to the eight classes which are persistent through all geological periods, per 1000 feet, in the Mesozoic strata than in the Palæozoic, and there are three times the number† of such species per 1000 feet in the Cainozoic strata that there are in the Mesozoic.

In the same year (1860), Professor Phillips, as President of the Geological Society, delivered the Anniversary Address to the Fellows, and again adverted to this subject, and the following quotation gives his conclusions, as delivered before one of the most critical geological audiences in Europe:—

"In the earlier periods of the world's history, the changes of life in the sea were accomplished at a rate *much less rapid than that which prevailed in later times*,‡ which agrees with the acknowledged very wide distribution of Palæozoic forms in geographical space. Admitting the changes of life on the whole to be equal from the Palæozoic to the Mesozoic, and from these to the Cainozoic periods, we find the rate of progressive change § $\frac{1}{70}$th for Palæozoic, $\frac{1}{18}$th for Mesozoic, and $\frac{1}{3}$rd for Cainozoic time,—a conclusion of great importance, and probably indicative of the greater influence and

or slow, in proportion as changes in climate and physical geography have been frequent or seldom. In the Palæozoic periods we have reason to believe that changes in physical geography were rare, while the climate and the nature of the earth's surface were very slightly diversified. In the Tertiary epoch, on the contrary, climate and physical conditions have been very diverse, and have frequently varied; and these variations have been accompanied by proportionate changes of species. If periods of small duration had been compared by Professor Phillips, it is quite certain that the chances of error would have been very great; but by putting in contrast only the three great epochs into which Geological Time has been divided, I believe that those chances of error have been reduced to a minimum, according to the well-known law of averages.—H. M. J. With all deference to so eminent a geologist as Professor Phillips, and to the author of this essay, it appears to me that such a table is an unsafe guide in the present state of the palæontological record. Here, for example, the fishes—the most important group of all, biologically—are entirely omitted.—EDITOR.

* According to my calculation, twice as many. † I make it six times.

‡ The italics are mine.—H. M. J.

§ Taking the unit of thickness such that it shall be $\frac{1}{100}$th of the ascertained strata in which life-traces occur.

superiority in early times of a slowly changing physical condition of the whole globe over the partial and irregularly varying local conditions, which were continually augmenting, and are still augmenting in influence with the lapse of time."

It may be objected to Professor Phillips's figures that he includes only the species belonging to the eight classes of animals which have been represented in each of the three great periods. I therefore give in the following Table the approximate total number of species (excluding plants only) that have been discovered in British stratified rocks up to the present time, with the result per 1000 feet, and the average number of feet per species in each great period:—

Periods.	Number of Species.	Maximum Thickness.	Relative Number of Species per 1000 feet.	Number of feet per Species.
Cainozoic	1,500	2,240	670	1·5
Mesozoic	4,000	23,190	173	5·8
Palæozoic	3,500	57,124	61	16·3

The evidence yielded by the analysis of these figures is even more in favour of the conclusion that the *rate of geological change*, according to the evidence of animal life, has progressively *increased* from the earliest to the latest times.

With one other numerical illustration I shall close the argument drawn from the organic phase of the question. The late Professor Bronn, in his prize essay, and in the third edition of his 'Lethæa Geognostica,' gives the following as the total numbers of known species in 1850, just twenty years ago:—Palæozoic 6681, Mesozoic 10,879, and Cainozoic 15,138. If we assume the maximum thickness of the deposits of these periods to be 60,000, 25,000, and 10,000 * respectively, we get the following numbers of species as occurring per 1000 feet of strata:—Palæozoic 111, Mesozoic 435, and Cainozoic 1513; thus showing exactly the same result almost in the same proportions.

The foregoing calculations are based on the assumption that the time required for the deposition of 1000 feet of strata was approximately the same in the Palæozoic, Mesozoic, and Cainozoic periods, and so far the argument is Uniformitarian; but the received interpretation of the physical conditions which prevailed in those periods renders it probable that the strata were deposited more slowly in the earlier than in the later periods, which, *a fortiori*, adds considerable strength to my conclusion.

The inorganic aspect of the subject has been discussed more

* I purposely make this number very large, so as not to run the risk of being charged with making too much of my argument from this point of view.

frequently than that phase which we have just reviewed; but with this striking difference, that no geologist has treated it from the point of view of pure geology in the same direction as Professor Phillips has from a palæontological standpoint,—the geological arguments are all either purely Uniformitarian, or as purely Catastrophic.

In the second of two essays "On the Measurement of Geological Time," which were published in 'Nature' only a few weeks ago,* Mr. Wallace touches on this question. He remarks † that for the last 60,000 years the eccentricity of the earth's orbit has been very small, and that therefore the opposite phases of precession, each lasting 10,500 years, have during that time produced scarcely any effect on climate. This state of things, however, is regarded by him, as by Mr. Croll, as quite exceptional, for during nearly the whole of the last three million years the opposite state of things has existed, namely, a high eccentricity coupled with a change (in the extra-tropical regions) every 10,500 years, from a very cold to a very mild climate. Mr. Wallace therefore argues as follows:—"This will necessarily have caused much migration both of plants and animals, which would inevitably result in much extinction and comparatively rapid modification. Allied races would be continually brought into competition, altered physical conditions would induce variation, and thus we should have all the elements for natural selection and the struggle for life to work upon and develop new races. High eccentricity would therefore lead to a rapid change of species, low eccentricity to a persistence of the same forms; and, as we are now, and have been for 60,000 years, in a period of low eccentricity, *the rate of change of species during that time may be no measure of the rate that has generally obtained in past geological epochs.*"

I shall not stop to criticize Mr. Wallace's attempt to measure geological time, as Mr. Dawkins has already pointed out the fallacy involved in the major premiss of this argument, *viz.* that all climatal change has depended solely on the eccentricity of the earth's orbit.‡ It is sufficient for my present purpose to point out that Mr. Wallace recognizes the principle that *the rate of change of species* may have varied in different geological epochs. To refer the cause of its variation to differences in the eccentricity of the earth's orbit is probably erroneous, but that error of ultimate explanation by no means diminishes the importance or the stability of the fact which is thus sought to be explained.

Both Sir Charles Lyell and Mr. Wallace have attempted to estimate the duration of the several geological epochs, basing their calculations on a supposed rate of change in species of marine mollusca. In this way Sir Charles Lyell concludes that "we may

* February 17th and March 3rd. † *Loc. cit.*, March 3rd, pp. 453 and 454.
‡ See 'Nature,' March 17, p. 505.

consider a million years to represent the twentieth part of a complete revolution in species, and we might thus estimate the number of years required for the elaboration of the successive Tertiary formations." Proceeding thus, Sir Charles Lyell calculates that two hundred and forty millions of years have elapsed since the beginning of the Cambrian period. Mr. Wallace, however, by taking the same facts and figures, manipulates them differently, and comes to the conclusion that the lapse of time is exactly one-tenth of that estimated by Sir Charles Lyell. This difference of result is of very little consequence, as both calculations are equally speculative, and it is chiefly to a point of resemblance that I wish to draw attention.

Sir Charles Lyell and Mr. Wallace, however much they may differ in other matters, whether they regard the revolution of species as having been accomplished in no less a period than twenty millions, or in one no greater than two millions, are agreed in using the same *rate of change* for the Palæozoic as for the more recent periods. Taking the figures of the latter author, and calculating the time required for the deposition of strata on his hypothetical rate of change in species, we get at the following results:—

Periods.	Duration (Wallace).	Thickness of Rocks (England).	Rate of Deposit; years per foot.
Cainozoic	6,000,000	2,240	2,678
Mesozoic	8,000,000	23,190	345
Palæozoic	10,000,000	57,124	175

It may be urged that the Tertiary rocks are comparatively thin in England, owing to the absence of Miocene deposits; but the same argument may be applied to each of the three periods with greater or less force; and at any rate the relative rapidity of deposit would not be very much disturbed if we took the maximum thickness all over the world instead of those occurring in the British Islands. Leaving denudation entirely out of the question, it does not seem at all probable that the Palæozoic rocks should have been deposited at the swift rate of one foot in 175 years; and if we deduct from the calculation the period represented by "breaks," which Professor Ramsay regards as longer even than that represented by strata, we shall have the conclusion drawn that the Palæozoic rocks were deposited at the rate of one foot in less than a century! At the present day there are many localities peculiarly favourable to the rapid accumulation of deposits over limited areas, as, for instance, the deltas of the great rivers; but even in such cases the rate of deposition is probably not more than what, according to Mr. Wallace's estimate, must have been general all over the aquiferous surface of the earth during Palæozoic times.

Whether we measure the relative lapse of time occupied by the successive events of Geological History by the known facts of the accumulation of deposits, or by the comparative changes which have occurred in the life of successive periods, we are led equally to infer that the *rate of geological change* has been more rapid in the later than in the earlier geological periods, and that that rate has increased progressively from the earliest to the latest times.

Such an inference, though it may at first sight seem heretical, is in reality but the natural result of those conditions of the earth's surface which the most orthodox geologists regard as characteristic of successive periods. A greater uniformity of climate and of surface in the earlier Palæozoic periods than at the present day has long been considered the legitimate inference to be drawn from the thick masses of uniform deposits spread over large areas, and containing species of fossils possessing an enormous geographical distribution. In ascending the geological scale the deposits gradually become more differentiated, and the fossils belong to species which had a more restricted geographical range; these differences are usually and properly regarded as the result of greater diversity of climate and surface-configuration during the later periods, and these more diversified conditions must have been accompanied by a greater rapidity in the rate of geological change, if for no other reason than that there were a greater number of *centres of change*, acting and reacting on each other.

IV. AIR-POLLUTION BY CHEMICAL WORKS.

A MANUFACTURER, having realized his primary object of making what he can out of the materials which pass under his hands, and having utilized all that he deems valuable in them, finds there is yet another need to be fulfilled; he must get rid of his refuse, and that as speedily as possible. Our present object is to watch this latter operation, and, losing sight of the beautiful or useful results of his work, to direct our attention to what is waste or refuse, and inquire how he disposes of it. When this is solid and bulky, it must be removed at the cost of much labour, and a place must be provided where it can be deposited. When the refuse is a liquid, the process of getting rid of it is generally less expensive; it will flow away in the water-courses if only proper drains and passages are provided. When the refuse is gaseous, this process of removal is easier still; no passages need be cut, no culverts nor bridges built, the vapour can be allowed to pass into the air, and is blown away.

In each of these cases the manufacturer's object is attained; he is rid of the refuse, and has room for renewed work. Unfortunately,

however, although he is rid of it, his neighbours are not so; they find, on the one hand, that the water of their brook is no longer fit for use, nor pleasant to look at, and the air they breathe is polluted with unsavoury and noxious vapours. Where a manufactory of this kind stands alone, or where only those who are dependent on it for their subsistence dwell in its vicinity, this state of things goes on for a long time without calling forth much complaint. Sooner or later, however, complaints must come; we cannot all live at arm's length. Population increases, we are pressed together, and valuable though the various products of manufacturing industry may be, pure air and pure water are more valuable still. Yet we cannot do without the manufactory, unless we return to barbarism. A naked savage eating uncooked roots erects no chimney to pour its black or acrid vapour into the air; he discharges the liquor from no dye back into the clear brook of the glen—but he remains a savage. We must keep our manufactories; by their products we are warmly clothed, our houses are firmly built and are decorated with colours; the wind is shut out by panes of transparent glass; the paper on which we write is white and fair. These and a thousand other things are the results of many a mechanical or intricate chemical process, the waste products from which, solid, liquid, and gaseous, are unpleasant enough.

If, then, we will not go back to barbarism to get rid of our smoke and our dirty water, can we go forward and by greater skill diminish or suppress them? The answer *must be* "Yes." Yet those only who have to work out the problem know with what difficulty this answer has in many cases been given, whilst in many it is not given yet.

The materials which the manufacturer throws away, we have already classed in correct school-room fashion as solid, liquid, and gaseous. With the first of these the manufacturer alone is concerned, and it may be safely left in his charge. The more of it he produces, the more must he expend in its removal, the more land must he purchase on which to deposit it; and if he throws away that which is valuable, he is the chief loser. We may, therefore, safely leave him, with certain reservations, to look after his solid refuse, knowing that no sharper impulse can be applied to induce him to diminish its amount, or to save what is valuable in it, than the spur of self-interest which already exists. We say it may be safely left in his charge; but if, through some process of fermentation or change, a portion of it shall slip out of his custody, and yield, after rain, a noxious liquid to drain into the nearest brook, or a gaseous escape to contaminate the air around, it falls back into the two other classes.

For the present we propose to direct attention to the latter of these two classes only, the gaseous. In doing so, we would first dwell

on the magnitude of the evil which may and does arise from the pollution of the atmosphere by gases discharged during the carrying on of various manufacturing processes; secondly, on the state of our laws on the subject; and thirdly, as to the direction which further legislation on the subject should take.

The evils complained of are not uniformly spread throughout the country, and do not come under the observation of everyone. Some districts are found to be specially suitable for carrying on a particular manufacture, so throughout the country we find works of a certain kind grouped together. Those who reside in the districts known as "manufacturing," are too familiar with the evils arising from noxious vapours floating in the air to need any setting forth of their extent, unless indeed familiarity with these evils has dimmed the perception of their magnitude. In Staffordshire, the so-called "black" country is a district of many miles in extent, blasted by the smoke of the iron furnaces; in it not a tree can be found, and scarce a blade of grass. Near St. Helens and Widnes in Lancashire scarce a living tree is seen in the direction towards which the prevailing winds blow, and in the valley of Swansea, thickly set with copper works, not only are the hill-sides bared of the green forests which once waved there, but the underwood, the shrubs, the hedge-rows, the grass itself is gone, and, to complete the desolation, when the roots and fibres which permeated the soil died and rotted, the soil itself, no longer able to withstand the action of the rain, was also washed away, leaving only bare heaps of stone and gravel. These, more like huge railway embankments than natural hill-sides, suffer yet another injury, for the rain, not now absorbed and held back by tree, shrub, grass, roots, or soil, falls on the bare hill-side, as on the slated roof of a house, and as quickly runs off it, ploughing the ground in its headlong course, making each rippling streamlet into a torrent even during a moderate shower. And still the desolation is not fully described, for when the even adjustment of nature is disturbed, who shall say where the derangement will stop? Here the grass, the soil is gone, and with these the insects and birds, with the exception of a few sparrows.

The manufacturing processes which may give rise to noxious vapours are numerous. The French, in the elaboration of their sanitary code, enumerate seventy-four.

These noxious vapours may do injury of two kinds—injury to animal life and to vegetation.

Injury of the former class, though real and widespread, is a matter less easily brought to the measure of money than that of the second class. People are annoyed at a vile smell arising from some manufacturing process, and by its continuance are affected in health, but they do not assess the damage in money and sue for it at law, except in so far as property is injured. Where, however, in

an already populous district a factory is established, the emanations from which can be proved to be injurious to human health, there is power for suppressing the nuisance; for, under the Sanitary Act (18 & 19 Vict., c. 121), the "Local authority, when moved by its Medical Officer of Health, or by two legally qualified practitioners, or by ten householders residing in the district in which the nuisance exists, is bound to complain to the magistrates (two lay, or one stipendiary) and to prosecute the offenders. The penalty, if the case is proved, is a fine of from 40*s.* to 5*l.* for the first conviction, 10*l.* for the second, and for each subsequent conviction a sum double the amount of the penalty imposed on the last preceding conviction, but so that such cumulative penalty do not in any case exceed 200*l.*"

The operation of the law here is clear, and generally satisfactory. This clearness, however, ceases when we turn to the working of the law in cases of injury done to vegetation. The question is not now whether any damage is done to the farmer's crops and trees, but *how much;* for if an important manufactory is carried on, giving employment to a large number of workmen, producing articles of general value, and returning a handsome income to the proprietor, it would not be wise to put a stop to all this producing power, because it of necessity entails a small amount of collateral damage. Rather let those who carry on this lucrative manufacturing business compensate those who are injured by it; and consider that they have only fairly earned that amount which remains, when from their gross profits they have deducted this charge. In this way we have a gauge by which to determine the amount of forbearance which the public shall exercise towards a manufactory doing obvious damage to the vegetation around it.

If a factory produces a revenue of 1000*l.* to its proprietors, and at the same time injures neighbouring vegetation to the extent of 100*l.*, it clearly does more good than harm. The farmer is compensated, and 900*l.* is honestly earned after every one is satisfied. Put, however, the figures the other way; suppose the works, while earning 100*l.*, to do 1000*l.* worth of damage, and the proprietors compelled to pay this, it will require no injunction from the Court of Chancery to make them close the works, or else to improve the manufacturing process so as materially to lessen the damage done.

But we have hitherto considered only the relations of the manufacturer and the farmer, imagining the smoking chimney to be surrounded by corn or clover, orchards and hedge-rows. All these have a known market value, and can be paid for with money. In place of the farmer, with his marketable crops, imagine him or his landlord dwelling in the old house of his fathers. The trees which surround his cottage or his mansion are of ancient growth; the place is his home. What money shall compensate for its loss? He may be rich and put little value on pecuniary compensation. He

will feel himself grievously wronged when, his trees being killed, he is offered money in place of them.

This might be said, however, in all cases where the sanctity of private property is invaded. When a railroad is planned, which is to carry a nation's traffic, it will disturb many an ancient hall and many a cottage home. The money equivalent is paid the owner, but in his eyes this is often no sufficient compensation. He must, however, bow to his fate and give way before the greater good of the many. So in the case where a man sees every year the noble trees vanish from his land, from the ancient domain that has been held in quiet enjoyment by his family through many generations, and feels himself driven from it by the advancing tide of manufacturers. He is much to be pitied; for, let him be paid ever so liberally for the damage actually done to the estate, he is not compensated. Yet he must submit and suffer personal loss for the public benefit.

Fortunately, however, these cases are exceptional; generally those interested in the land can be fully compensated in money for all they lose. A farmer, who should get 100*l.* for the produce of his wheat-field, is content if it brings him in only 50*l.* in the market, provided he can get the remaining 50*l.* by way of damages from the neighbouring chemical manufactory. A question here at once arises, Will he have much difficulty in obtaining from the manufactory the 50*l.*, the proved amount of his loss? If the manufactory is standing by itself, he probably will have no great difficulty. If the demand is resisted, his course at law is plain. He proves that on a certain day, or on many days, the smoke of the offending chimney was seen to fall upon his land, that soon afterwards the crops were visibly injured, in such a way as is known to be caused by chemical smoke; he also further proves, by the assistance of agricultural valuers, that the amount of the damage done is an equivalent of the sum of money he now claims. This chain of evidence is usually so conclusive that the farmer wins the day.

Suppose, however, that in place of one chemical work being near the farm, there are several in a group, from all of which the smoke approaches simultaneously. These works may be of different kinds; there may be alkali-works and copper-smelting works; glass-works and potteries, with chemical works whose various processes and products defy enumeration, how shall the farmer discriminate, or rather how shall he criminate? how shall he fix on the culprit among such a motley crowd of evil doers? Let us suppose him calling on the first in order, and making his complaint against him, as the one he thinks most likely to have been the offender; the manufacturer explains to him in the clearest manner that from the nature of the processes he carries on, and the care with which all injurious vapours are avoided or condensed, he

cannot have injured the land; perhaps it was his friend of the neighbouring works, whose processes are different from his own. Doubtless this gentleman would be equally clear and conclusive in his explanations, and would pass our farmer on once more, to be sent in turn from one to the other, but to get redress from none.

The farmer soon learns that the only way in which he can obtain compensation from any of the chemical manufacturers is to fix on one of the works, perhaps the one nearest his land, or the one with the highest chimney, and to watch till he thinks he can distinguish the smoke from it come upon his farm. On that he fixes, and, shutting his eyes to the other works and forgetting the injury they probably do him, charges the proprietor with the whole of the damage he has sustained. The judges and juries before whom such cases come for trial are in great difficulty, they know that the manufacturer in question has not done all the damage alleged, yet they have no power of apportioning it between him and other offenders, therefore, as some of the damage has been proved to come from the defendant's works they give a verdict for the plaintiff.

Among chemical works, the largest, and those capable of doing most harm to vegetation, are the alkali-works. In these works soda, in its various forms of ash, carbonate, bicarbonate, crystal or caustic, is extracted from common salt. Common salt consists of soda in combination with muriatic acid. When it is mixed with sulphuric acid and heated, muriatic acid is driven off as a gas. In the earlier days of the soda manufacture this acid was considered as a waste product to be got rid of as speedily as possible. The easiest way was to let it pass into the chimney and thence into the surrounding atmosphere. Complaints were soon made that trees in the neighbourhood were injured. The manufacturer therefore raised his chimney, building it so high that the acid might be carried away to a great distance by the wind and its effects lost sight of. The result of this effort was not successful; on wet days the rain passing through the smoke would wash down the acid and fall in burning drops even at the foot of the chimney; while on fine days the smoke would travel farther and though much spread out, still powerful for evil, would carry on its destruction over a larger area. A wiser plan was next adopted; by the use of the now famous Gossage condensing towers the acid vapours were washed out of the smoke and kept from contaminating the air altogether. Those alkali manufacturers who carried out this method well sent out scarcely any acid vapour to damage the farmers' crops. Some of the manufacturers, however, were behindhand in the movement, and either from want of skill or of enterprise, did not condense their acid vapours. Of the efficiency of this condensation in individual cases the farmer could not judge; he found that his crops

were still damaged, and therefore brought his action as before, possibly to recover from an innocent party. At this point the Legislature stepped in, and in the Alkali Act of 1863, passed a measure which has worked well in the interests of both the manufacturers and the agriculturists. The Act announces it to be the duty of the manufacturer to condense 95 per cent. of the muriatic acid he produces, and fixes a penalty of 50*l.* for each omission, raising the penalty to 100*l.* after the first conviction. Inspectors are appointed, whose duty it is to visit the works from time to time and ascertain that the provisions of the Act are carried out. It should be noticed that the Legislature in passing this Act stepped out of its accustomed course. The common law maxim is that for every injury a man may receive he has his remedy against some one. He must, however, receive the injury before he can seek his remedy; but in this case, as it already has been shown, much injury may be done which has no remedy. Who can replace an oak tree of 100 years' growth and restore the waving woods which adorned the hill side? The law therefore here steps in beforehand, and no sooner does the Inspector find that 95 per cent. of the acid is not condensed, than he stops the process under the penalties mentioned. The new law has been found to work very well, it has enforced the condensation of muriatic acid to the benefit both of the manufacturer himself and of the public. It has protected the agriculturist against the manufacturer, and the manufacturer against the agriculturist. The Inspector is received as a friend by both sides; he protects the farmer's interests by enforcing care on the part of the manufacturer, and he protects the manufacturer's interest by proclaiming the extent to which he carries the suppression of noxious vapours. The Act has had the effect of bringing up the hindermost manufacturer to the rank of the most skilful. Before this legislation took place many manufacturers condensed a portion of their muriatic acid; now they all condense not a small portion only, but fully 95 per cent., some indeed habitually condense 99 per cent. The manufacturer finds the visits of the Inspector an assistance to him in keeping his condensing apparatus in efficient order; and an amount of acid escaping which would pass unnoticed by the master or his workpeople is detected by the Inspector. It should be understood that to point out leakage of muriatic acid is to point out waste, for this acid is needed in the manufacture of bleaching powder, and other products. The amount of acid thus saved by the operation of the Act is very large. One manufacturer sells muriatic acid annually to the amount of 1500*l.*—acid which previous to the passing of the Act was sent up the main chimneys of the works to the destruction of all surrounding vegetation.

It may now be asked in general terms, has the Alkali Act, this somewhat experimental law, succeeded; does it accomplish the work

it was intended to do? The reply is that it has done all and more than its promoters or those who understood its provisions expected; but probably the public generally are not satisfied; they fail to understand that a law which professes to shield them from muriatic acid cannot also defend them from chlorine, sulphurous acid, sulphide of hydrogen, and the host of nameless gases by which their noses and their gardens are assailed; still less can they understand that an Act which should prevent the emission of muriatic acid from the chimney of an alkali works, cannot also prevent the escape of the same acid from copper-extracting works, a bottle factory, or a pottery.

The Act must, however, not be blamed for omitting to do that which it was never framed to accomplish; let us be glad that a step has been gained, that one noxious gas has been measured and suppressed.

Some instances have occurred where manufacturers who are not alkali makers have desired to place their factories under the Inspector appointed under the Alkali Act. Their object being first to know if, in his opinion, they were sending out an injurious amount of noxious vapour, then, having diminished it so as to meet with his approval, to gain his advocacy and defence when harassed by their natural enemies the farmers. This has brought a certain amount of volunteer work on the Inspectors, which they have cheerfully borne on account of the obvious good they could accomplish, by diminishing on the one hand the escape of noxious acids, and preventing litigation on the other.

In districts such as that around St. Helens, in Lancashire, where alkali-works and copper-smelting works are found together, the copper smelters look somewhat enviously at the alkali makers.

Before the passing of the Alkali Act, the farmers who thought they had suffered loss through the injury of their crops by acid vapours, charged the damage sometimes against the alkali-works and sometimes against the copper-works. Now, however, owing to the improvements which have been made in the alkali-works under the stimulus of the Act, and supposing the manufacturers to be somewhat protected by it, the landholders direct their attacks exclusively against the copper smelters. The amounts claimed by each farmer are not always large, but the aggregate has reached 3000*l.* a year against the six copper-works.

Besides these smaller claims an important action was lately brought by the proprietor of an estate three miles from St. Helens against a copper smelter, for damage done to his trees and crops by the smoke from the works. The course the action took, so well shows the present working of the law, and indicates perhaps the direction in which it could be amended, that it might be well to give some account of it here.

The plaintiff proved he had received damage from smoke coming from the direction of the defendant's works, and alleged that the damage he had sustained was wholly done by them, intimating that if he gained a verdict in the present suit he should apply to the Court of Chancery for an injunction to restrain the carrying on of the works altogether, as he believed he would then be free from all damage. In defence it was pointed out that the defendant's works lay in a straight line between the plaintiff's land and St. Helens, so that the same wind which brought defendant's smoke would also convey the smoke from a large portion of St. Helens, and that in general, as the plaintiff's park was subject to injury from all the factories in the neighbourhood, it was unjust to charge the whole damage upon the defendant.

It will be seen that the following question would at once present itself:—Is it possible to determine the amount of damage which each factory in a district contributes towards the damage done by all?

In other words, if a farmer sustains a loss of 100*l.* through his crops being injured by the accumulated smoke of a manufacturing district, is it possible to set down to each manufacturer the amount which he ought to contribute towards this 100*l.*?

Turning to the fifth of Dr. R. Angus Smith's very able reports under the Alkali Act, we find this question anticipated and an answer given. Referring to the amount of acid vapours thrown up with the smoke of factory chimneys, he says at page 25:—"Now it is easy to estimate this amount, and it is easy to put down to every one in the district the exact share of guilt so far as the acid is concerned. . . . . Perhaps we may also bring in the element of distance."

In consequence of this Mr. Alfred E. Fletcher, the Inspector under the Alkali Act for the district which includes West Lancashire, was asked to apply himself to the question. He had to consider:

1st. The distance of each factory from the injured land.

2nd. The rate at which the increase of distance diminishes the power of the smoke to do damage.

3rd. The number of days throughout the year on which the wind blows from each point of the compass.

4th. The amount of acid vapour discharged from each factory in a given time.

First, the distances; these are easily measured on the map.

Information on the second point was obtained in the following manner. At a time when the ground was covered with snow for a week, lines were drawn, in a direction following the wind, from St. Helens and from other groups of works, to a distance of two or three miles. At each half-mile a sample of the surface snow was collected and brought home for analysis. Also during a period of rain, collecting vessels were set at regulated distances from a group

of works. A determination was then made of the amounts of muriatic and of sulphuric acids collected by the snow and by the rain, and these were compared with the distances at which the samples had been obtained. It was seen that the amounts diminished in even ratio with the increase of distance. Probably a sufficient number of experiments of this nature have not yet been made, firmly to establish the law; for the undulations of the ground, the position of trees, and any objects which interfere with the uniform motion of the air, affect the even deposition of the acid vapours. More experiments, it was said, were about to be undertaken in order to establish the law on a wider basis. Information on the third point may be usually obtained at some neighbouring observatory. In the case of St. Helens the returns of the direction of the wind, published at the Liverpool Observatory, on Bidston Hill, were depended on.

Fourthly, the amount of acid vapour discharged from each factory in a given time can be known by periodical examination of the gases which are passing up the various chimneys of the works. This is already done as far as the alkali-works are concerned under the provisions of the Alkali Act. In the cases of copper-smelting works, glass-works, and others where systematic inspection has not been carried on, the amounts of acid vapour thrown into the air can be calculated from the materials used in the manufacturing processes carried on.

The acid vapours discharged from the various works in the St. Helens district are:—From ten alkali-works,—muriatic acid, sulphuric acid, sulphurous acid, nitrous acid, chlorine, coal smoke; from nine glass-works,—muriatic acid, sulphuric acid, sulphurous acid, vapour of common salt, coal smoke; from six copper-smelting works,—sulphuric acid, sulphurous acid, coal smoke; from six collieries, six iron foundries, two soap-works, 8000 dwelling-houses, —coal smoke; from the Sankey Brook and the heaps of alkali waste,—sulphide of hydrogen.

This is a formidable list, but the amounts of each may be calculated with a very near approach to accuracy, except the last item, the sulphide of hydrogen, which varies continually with the amount of rain-fall, and with the temperature of the air.

Having, then, collected the information as set forth under these four heads, it became merely a question of figures to apply it to the solution of the problem raised in the St. Helens law-suit. A list was made out of the principal factories in the district capable of doing injury to the plaintiff's land. Opposite these was set down the distance of each factory from the land and, in a parallel column, the amount of acid vapour thrown up by each. On dividing the figures in the second column by those in the first, numbers were obtained which were proportioned to the share each one had contributed to the total damage done by all to the plaintiff's land.

XUM

Further, a method was adopted by Professor Roscoe, of Owen's College, Manchester, which confirmed the accuracy of this calculation.

St. Helens lies, as has been said, three miles from the plaintiff's park, defendant's works being half-way between them.

While the snow lay on the ground last February, the wind blew mainly from the east. Professor Roscoe then took samples of the snow lying three miles west of St. Helens, and also some of that lying a mile and a half west of defendant's works, that is, the same distance to the west as plaintiff's land is to the south-south-east. He found that the proportion of the amount of acid contained in the one to that contained in the other, agreed closely with the proportion determined by Mr. Fletcher in the previous calculation. This was given as evidence at the trial, and it appears that the jury acted on the principle here laid down, that a manufacturer should only be called on to pay in proportion to the amount he contributes to the total damage sustained, and that it is possible to ascertain what that amount should be. Since this trial two other similar cases have been decided by arbitration, in each of them the arbitrator showed by his award that he adopted the principles here set forth.

Having now given some account of the working of the Alkali Act, the most recent legislation on the difficult subject of air-pollution, and sketched the action of the law courts when matters of the kind are brought before them, it may be desirable to discuss the course which further legislation should take in the matter.

As regards the present Alkali Act, we would object that though successful it is too limited in its application.

Secondly, the onus of carrying out its penal clauses rests on the Inspector. We should have a noxious vapour Act applicable to every manufacture where injurious gases are thrown off. The duty of the Inspector should be solely to inspect and to publish the results of his inspection—the public should be the prosecutors.

Let us follow the working of such an Act. In every district its Inspector would, from time to time, publish a list of the works, together with the amounts of acid or other vapour escaping from them. This would be given either as the amount in 1000 cubic feet of the chimney gases, or the actual amount by weight of that which escapes per month or per annum. The result of this to the manufacturers would be that they would anxiously consult the published list and exercise a wholesome rivalry as to who should stand well in it. Moreover, these lists would form the basis for assessment of damages in case of claims made by the neighbouring farmers. A pecuniary stimulus would thus also be given. To the neighbouring farmer or landholder these lists would be invaluable; they would show him where to apply with the best

chance of success for compensation for proved loss by noxious vapours; or enable him to apportion his claim among several works, in proportion to their places in the list and their relative distance from his land.

Thus in place of the goading influence of a few isolated and sudden prosecutions, a gradual pressure onwards would be felt, a constant stimulus to improvement. All chemical manufactures cannot be embraced in the provisions of an extended Alkali Act until for each separate noxious vapour a process of suppression can be described, and a limit for its working defined. But with such an arrangement as is here proposed, all noxious vapours without the task of enumeration would be at once legislated for. If there are several manufacturers carrying on the same processes in the same district, and one of them by special ingenuity discovers some process by which a large portion of the acid vapour he has hitherto sent away may be condensed, he improves his place in the *list*, and so enjoys immunity from actions for damage on the part of the farmers. The other manufacturers would obviously be compelled to follow him in the race of improvement. Thus all would be brought up to the rank of the foremost, and there would be a constant impulse to the manufacturer to reduce the noxious emanations from his works within the smallest possible amount.

V. DE MORTUIS.

By Henry Woodward, F.G.S., F.Z.S., &c.

In almost all countries, both among savage and civilized races, the rites of sepulture have been looked upon as a debt so sacred that those who neglected it were considered infamous.

The Greeks and Romans believed so strongly in the importance of this obligation that they considered it to be fatal to their admission into *Elysium* to neglect to do honour to the dead.

Nor can the practice of honouring the dead be claimed by these classical countries alone, for throughout Egypt, Palestine, Persia, India, and China, are monuments of the most lasting and costly description raised to the mighty dead.

That the more northern and western races of mankind possessed the same traditions cannot be doubted, and although their monuments are of a ruder character they display often a vast amount of labour in their construction, and an equal care for the departed whose remains they were intended to preserve.

On the rude but colossal "Megalithic Structures of the Channel Islands, their History and Analogues," a very able and exhaustive

article by Lieut. S. P. Oliver, Royal Artillery, F.R.S., appeared in the 'Quarterly Journal of Science' for April last, to which it is only needful here to refer our readers.*

Fortunately for the archæologist the uninviting exterior of these northern and western tombs has been, until of late years, a means of protecting them to a great extent from pillage; for within these rounded dome-like hills of earth (Tumuli) are often discovered relics of a period so remote that, save for these sacred depositories, we never could have hoped to obtain any reliable information of the builders, or to have learnt aught of their advance in civilization, or of the arts they practised.

The rich and varied discoveries of the Swiss Lake habitations indeed, have thrown much new light upon the early history of Europe, yet many writers have nevertheless concluded that these remains are, after all, not much more than two thousand years old, seeing that similar lacustrine habitations were known to Hippocrates (B.C. 460), and Herodotus (B.C. 404). But the careful researches of Prof. Keller, and many other investigators, prove beyond question that these settlements go back to the early Neolithic period, if not to the palæolithic.

In speaking of the ages of Stone, Bronze, and Iron, however, we should always guard against the notion that, at any one time, save in the very earliest palæolithic stage, one material for the manufacture of implements was used exclusively over the whole of the Continent. Not only does the "Iron age" stretch from our own time back to an antiquity more remote than Nineveh, but the "*Bone* age" is still extant and has overlapped all the other divisions, for horn and bone are still used by civilized man, and our most remote ancestors we know discovered the economic value of the bones and horns of the first animals they slew in the chase.

Therefore in the examination of all early remains many collateral circumstances must be taken into account before we can justly assign an approximate date to any discovery. For instance, if we grant that the civilization of man actually ran its course through these periods, just as they are mentioned above, yet it is certain that the Bronze period of Northern Europe by no means agrees in time with that of the middle and southern parts of this Continent.

Again, the Bronze age of Greece and Italy may be separated by centuries from that of Egypt, which we may consider as the cradle of western civilization.

We may safely conclude, as the Danish antiquaries themselves allow, that in the Scandinavian countries stone implements were for a length of time used while the Bronze period was in full activity in the more southern lands, and that Egypt, whose oldest monuments indicate very clearly the use of iron, and also Greece, had both ad-

* Vol. vii., p. 149.

vanced to the Iron period when Central Europe was in the Bronze age. If, therefore, according to the testimony of ancient authors and monuments, bronze and iron were used in the earliest ages in the countries round the shores of the Mediterranean, the commencement of these periods in the inland and northern parts of Europe was regulated entirely by the greater or less amount of intercourse between these countries and those to whom we are indebted for a knowledge of metals, so essential to civilization. We may even at the present day observe a similar irregularity in the distribution of the products of higher civilization and art. Nor do these divisions give us any positive certainty; for in very few burial places or early settlements are the remains found so purely distinctive as to enable us conclusively to attribute them to any one of the three periods.

It seems very certain that there was no hard line of demarcation between the three periods, but that the new materials were spread abroad like any other article of trade, and that the more useful tools gradually superseded those of less value.*

We should hardly, writes Sir John Lubbock,† have hoped to ascertain much of the manner in which the people of the Bronze age were dressed. Considering how perishable are the materials out of which clothes are necessarily formed, it is wonderful that any fragments of them should have remained to the present day. There can be little doubt that the skins of animals were extensively used for this purpose, as indeed they have been in all ages of man's history; many traces of linen tissue also have been found in English tumuli of the Bronze age and in the Swiss lakes. Even a single fragment throws much light on the manufactures, if we may call them so, of the period to which it belongs; but fortunately we need not content ourselves with any such partial knowledge as this, as we possess the whole dress of a chief belonging to the Bronze age.

On a farm occupied by M. Dahls, near Ribe, in Jutland, are four tumuli, known as Great Kongehoi, Little Kongehoi, Guldhoi, and Treenhoi. This last was examined in 1861 by MM. Worsaae and Herbst. It is about 50 ells in diameter and 6 in height, being composed of a loose sandy earth. In it, near the centre, were found three wooden coffins, two of full size, and one evidently intended for a child. The coffin with which we are now particularly concerned was about 9 feet 8 inches long and 2 feet 2 inches broad on the outside; its internal measurements were 7½ feet long and 1 feet 8 inches broad. It was covered by a movable lid of corresponding size. The contents were peculiar and very interesting.

While, as might naturally be expected, we find in most ancient graves only the bones and teeth, all the soft parts having long ago decayed away, in some cases—and this was one of them—almost

* Keller's 'Lake-Dwellings:' translated by J. E. Lee, F.S.A.
† 'Pre-historic Times.'

exactly the reverse had happened. Owing to the presence of water, and perhaps to the fact that it was strongly impregnated with iron, the soft parts of the body had been turned into a dark, greasy, substance (*adipocere?*); and the bones, with the exception of a few fragments, were changed into a kind of powder.

Singularly enough, the brain seems to have been the part which had undergone the least change. On opening the coffin it was found lying at one end, where no doubt the head had originally been placed, covered by a thick hemispherical woollen cap, about 6 inches in height. The outer side of the cap was thickly covered by short loose threads, every one of them ending in a small knot, which gave the cap a very singular appearance. The trunk of the corpse had been wrapped in a coarse woollen cloak, which was almost semicircular, and hollowed out round the neck. It was about 3 feet 8 inches long, and broad in proportion. On its inner side were left hanging a great number of short woollen threads, which gave it somewhat the appearance of plush. On the right side of the corpse was a box, closed by a lid, 7½ inches in diameter, 6¼ inches high, and fastened together by pieces of osier or bark. In this box was a similar smaller one, without a lid, containing three articles, namely, a cap 7 inches high, of simply woven woollen stuff; a small comb, 3 inches long by 2½ inches high; and a small simple razor-knife. The coffin also contained two woollen shawls, one of them covering the feet, the other lying higher up; they were square in shape, 5 feet long, 3 feet 9 inches broad, and with a long fringe.

At the place where the body had lain was a shirt, also of woollen material, cut out a little for the neck, and with a long projecting tongue at one of the upper angles. It was fastened at the waist by a long woollen band, which went twice round the body, and hung down in front. On the left side of the corpse was a bronze sword in a wooden sheath, 2 feet 3 inches in length, having a solid simple handle. At the feet were two pieces of woollen stuff about 14½ inches long and 3½ inches wide, the use of which does not seem quite clear, though they may be supposed to be the remains of leggings. At the end of the coffin were found traces of leather, doubtless the remains of boots. In the cap where the head had been was some black hair, and the form of the brain was still recognizable. Finally, this ancient warrior had been wrapped round in an ox's hide, and so committed to the grave. The other two coffins were not examined by competent persons, and the valuable information which they might have afforded is lost to us. The more indestructible things were, however, preserved; they consisted of a sword, a brooch, a knife, a double-pointed awl, a pair of tweezers, a large double button or stud, all of bronze; a small double button of tin, and a javelin-head of flint.

The "Kongehoi" contained four wooden coffins, in which were bodies clothed in woollen garments, a bronze sword in a wooden sheath ornamented with carvings, two bronze daggers, a wooden bowl ornamented by a large number of tin nails, a vase of wood, and a small box of bark.

There can, therefore, be no doubt that these very interesting tumuli belonged to the Bronze age, and I am inclined (says Sir John Lubbock) to place them somewhat late in the period, partly on account of the knife and razor-knife, both of which are forms referable to the close of the Bronze period, and to the beginning of that of Iron. Bronze brooches are also very rarely found in the Bronze age, and are common in that of Iron. The sword, again, belongs to a form which Professor Nilsson regarded as being of late introduction. The mode of interment may also be regarded as unusual in the Bronze age, though commonly so found in interments of the Iron age.

In Denmark cremation appears to have been all but universal, and seems plainly to betoken the south-eastern origin of the peoples who practised it. Bateman and Sir R. C. Hoare, record a number of instances of graves opened by them in England containing objects in bronze which well illustrate the prevalence of burning the dead:—

	Body contracted.	Burnt.	Extended.	Position uncertain.
Number of cases..	19 ..	59 ..	7 ..	15

Canon Greenwell also mentions that out of 100 interments with bronze ornaments, &c., examined by him, all were either burnt or the body was placed in a sitting posture. Of the wide-spread practice of interment in a sitting posture, we may find abundant instances in Wilson's 'Pre-historic Man.' Thus* in opening a Peruvian tomb it is stated "the male mummy was that of a man in the maturity of life, *in the usual sitting position*, with the knees drawn up to the chin." We should certainly consider this mode of interment to be the most primitive.

If ornaments, weapons, or coins in any number, be found in the grave, or if much labour has been bestowed upon its construction, we may justly infer that, to whatever period the grave may belong, it was the last resting-place of a chief or warrior of the tribe; for the same causes which operate now to deter the poorer classes from a lavish expenditure upon the dead, acted in early times still more strongly, when every article of dress and every weapon being required for daily use were of so much greater intrinsic value, and consequently the devotion which instigated their dedication to the use of the departed must have been either the result of strong attachment, or a display of the affluence of the family to which the deceased belonged.

There can be no doubt that the introduction of Christianity was

* At p. 440.

the means, not only of putting an end entirely to the practice of incremation, but also to a great extent to that of depositing votive offerings in the graves of the departed. The introduction of such sentences as those which our burial-service contains, against the thought that we can take anything with us out of the world, evidently when introduced by the early Church had reference to the heathen practice of placing objects highly esteemed in the grave with the dead.*

Schiller's lines (translated by Lytton) well express this practice so common among the aborigines of our own day:—

"Here bring the last gifts! and with these
The last lament be said;
Let all that pleased, and yet may please,
Be buried with the dead.

Beneath his head the hatchet hide
That he so stoutly swung;
And place the bear's fat haunch beside—
The journey hence is long!

And let the knife new sharpened be
That on the battle-day
Shore with quick strokes—he took but three—
The foeman's scalp away!

The paints that warriors love to use,
Place here within his hand,
That he may shine with ruddy hues
Amidst the spirit-land."

It not unfrequently happens that fragments of the bones of sheep and other animals are found in cinerary urns associated with the human remains. This is easily explained when we consider the manner in which the rites to the dead were performed.

If the dead person were a chief or warrior of note, it was usual to erect a funeral pyre of great size, upon which the corpse was laid, surrounded by the bodies of various animals slain in honour of the dead, together with costly unguents and perfumes. Frequently a number of slaves and captives were also sacrificed to the *manes* of the departed. Thus, in Homer's 'Iliad,' we have a graphic description of the death of Patroclus during the Trojan war, and the honours paid to his body by Achilles and the Greeks:—

"While those deputed to inter the slain
Heap with a rising pyramid the plain.
A hundred feet in length, a hundred wide,
The growing structure spreads on every side;
High on the top the manly corse they lay,
And well-fed sheep and sable oxen slay:
Achilles covered with their fat the dead,
And the pil'd victims round the body spread;

* Rolleston 'Archæologia,' vol. xlii.

Then jars of honey, and of fragrant oil,
Suspends around, low-bending o'er the pile.
Four sprightly coursers, with a deadly groan
Pour forth their lives, and on the pyre are thrown.
Of nine large dogs, domestic at his board,
Fall two, selected to attend their lord.
Then last of all, and horrible to tell,
Sad sacrifice! twelve Trojan captives fell.
On these the rage of fire victorious preys,
Involves and joins them in one common blaze."*

During the ceremony, decursions and games were celebrated, often lasting several days, after which the *ossilegium*, or gathering of the bones and ashes of the dead, washing, anointing, and depositing in urns, was performed.

Amongst refined and civilized peoples it is possible to conceive that a certain sacredness was connected with this ceremonial, and that such lines as the *Salve Eternum* might form an appropriate conclusion of such service:—

"Farewell, O soul departed!
Farewell, O sacred urn!
Bereaved and broken-hearted,
To earth the mourners turn!
To the dim and dreary shore,
Thou art gone our steps before!
But thither the swift hours lead us,
And thou dost but awhile precede us!
Salve—Salve!
Loved urn and thou solemn cell,
Mute ashes!—farewell, farewell!
Salve—Salve!"†

But the incremation ceremony in western and northern Europe was in reality more an occasion of feasting; the slain animals being chiefly cooked and eaten by the mourners. Thus we find in Anglo-Saxon barrows and graves in England abundant remains of animals, especially those of the horse, which have served as feasts.

To so high a pitch had this practice of the lyke-wake risen in later times that it was severely denounced in numerous inhibitions issued by the early Church.‡

Judging by the number of instances in which gold ornaments have been found in graves, it seems probable that gold was the metal which first attracted the attention of man. Its bright colour would certainly attract even the rudest savages, who are known to be very fond of personal decoration.

Silver does not appear to have been discovered until long after gold, and was apparently preceded by both copper and tin, as it is rarely, if ever, found in tumuli of the Bronze age; but however this may be, copper seems to have been the metal which first became of real importance to man; no doubt owing to the fact that its ores

* Pope's Translation of the 'Iliad,' Book xxiii.
† 'Last Days of Pompeii:' Lytton.
‡ See Rolleston in 'Archæologia,' vol. xlii.

are abundant in many countries, and can be smelted without difficulty; and that, while iron is hardly ever found except in the form of ore, copper often occurs in a native condition and can be beaten at once into shape.*

There is no reason to suppose that the mound-builders, whose earth-works occupy leagues in extent in the valleys of the Mississippi and Ohio, were acquainted with the art of smelting copper; that they mined it extensively on the shores of Lake Superior, and wrought it into knives, spear-heads, chisels, and bracelets, and other personal ornaments there can be no reasonable doubt, but having no tin, they could not, like the ancient dwellers of the Swiss lakes, Denmark, &c., impart to the alloy almost the hardness of steel. It is doubtful, even, whether their metallurgic art extended to the smelting of copper; for it often happens that the native copper of Lake Superior encloses native silver, both metals existing side by side chemically pure, which, if smelted, in whatever proportions, would form a homogeneous compound. Bracelets have been found in the mounds, in which this peculiarity is preserved, thus showing that the material had not been smelted but simply hammered cold; and the ends are brought together by bending, without any evidence of having been soldered.†

Of the amount of gold found in the Chiriqui graves in Central America probably no just estimate can be obtained. At the period of Mr. Power's visit in August, 1859, about 250 lbs. weight of gold had been extracted from the *huacas* at Bugábita, two-thirds being tolerably pure gold, the remaining third what is called "guanin," or gold alloyed with copper; the value of the whole was about 12,500*l.* In the summer of 1861, some fresh tombs were discovered from which gold objects to the value of 16,000*l.* had been extracted.‡ Although, as must necessarily happen, these interesting remains find their fate in the melting-pot wholesale, there are yet to be seen in the Blackmore Museum at Salisbury, the Christy Museum, Victoria Street, the British Museum, and elsewhere, many examples of these curious American antiquities.

From a careful examination of many of the Ohio mounds and a comparison of their characteristics with ancient Scandinavian tumuli, it seems highly probable that, in some instances at least, the tomb was formed by covering the dwelling in which the dead man had lived with a mound of earth or a cairn of stones.

This would explain the curious sorted condition of many remains in the American mounds. Thus in mound No. 8, "Mound City," may have been buried the body of some celebrated pipe-maker, with all his stock-in-trade, which his friends no doubt believed he would

* Lubbock, 'Pre-historic Times,' pp. 3–4.
† Foster's 'Mississippi Valley,' p. 423.
‡ 'Flint Chips,' by E. T. Stevens, pp. 285–6.

find valuable to him for barter in the land of spirits as he had done in this world. In others the stock of arrow-heads was so enormous we may well suppose the occupier of the mound had been a maker of flint arrow-heads.

The practices of modern savages often throw great light upon these difficult points.

Thus we find among the New Zealanders, if the owner dies, he is commonly buried in his house with all it contained.* The islanders of Torres Straits also used their dwelling-huts as dead-houses.† It is still more significant that the Esquimaux themselves frequently leave the dead in the houses which they occupied when alive.‡ We cannot, says Sir John Lubbock, compare the plan of a Scandinavian "passage-grave" with that of an Esquimaux snow-house, without being struck with the great similarity existing between them.

Under these circumstances there seems much probability in the view advocated by Professor Nilsson, the venerable archæologist of Sweden, that these "passage-graves" are a copy or adaptation of the dwelling-house; that the ancient inhabitants of Scandinavia, unable to imagine a future altogether different from the present, or a world quite unlike our own, showed their respect and affection for the dead by burying with them those things which in life they had valued most; with women their ornaments, with warriors their weapons.

They buried the house with its owner, and the grave was literally the dwelling of the dead.§

From the foregoing premises we may venture to establish this axiom, namely, that any people who accompanied the rites of interment of their dead by such evident indications of care and attention as we find in a vast number of graves belonging to different periods and races in Western Europe and America, may be safely concluded to have possessed a notion of a future state, whatever may have been the name they ascribed to it; and moreover they must have also believed it possible, by their gifts and good offices, to assist their departed friends into the spirit land.

* Tylor, 'New Zealand and its Inhabitants,' p. 101.
† M'Gillivray, 'Voyage of Rattle-snake,' vol. ii., p. 48.
‡ Ross' 'Arctic Expedition,' 1829-33, p. 290.
§ Lubbock, 'Pre-historic Times,' pp. 126-7.

VI. FOREIGN TREES AND PLANTS FOR ENGLISH GARDENS.*

By Alfred W. Bennett, M.A., B.Sc., F.L.S.

The introduction of new forms of vegetable life into our gardens and greenhouses has made considerable progress during recent years. The Acclimatisation Societies of Paris and London have, it is true, paid more attention to the domestication of foreign animals than of plants; something, however, has been attempted in this direction, and with considerable success. This branch of acclimatisation would, indeed, seem likely to be the most fertile in results beneficial to mankind. For one fresh animal introduced that will be of real utility, there will probably be a dozen plants that yield important economical products. The early races of mankind appear to have exhausted our powers over the lower animals—the horse, the ass, the dog, the camel, the ox, the sheep, were all brought under subjection to man at the earliest period of his history; and within historic times no important addition has been made to the number of our domestic animals. Not so with plants. A large number of the vegetable substances used as food at the present day, and of the vegetable articles of manufacture, were unknown to the ancients; and the field for further extension of our utilisation of the vegetable kingdom seems indefinitely large. The power of cultivation in modifying plants is also much greater than any corresponding power of domestication in modifying animals. The oldest extant drawings of the horse, the ox, or the camel, scarcely point out any distinctive features from their descendants now living; the potato and the apple, on the other hand, may almost be considered as manufactured products; while many gardeners' flowers, such as the Pelargonium and the Tulip, differ so widely from their ancestors as, in some cases, to obscure their parentage. The term Acclimatisation has been objected to by some scientific men, on the ground that the descendants of any animal or plant which has been transported from one climate to another have no more power than their ancestor of adapting themselves to that climate, unless the principle of Natural Selection has come into play to eliminate the individuals least able to adapt themselves to the new climate, those only surviving which, from some cause or other, are most suited to the fresh conditions. Be this as it may, there is no question about the fact that the farmer

* 'The Planter's Guide: Trees and Shrubs for English Plantations.' By A. Mongredien. London: J. Murray. 1870.

'Alpine Flowers for English Gardens.' By W. Robinson, F.L.S. London: J. Murray. 1870.

'Dendrologie: Bäume, Sträucher, und Halb-sträucher welche in Mittel oder Nord-Europa im Freien kultivirt werden.' Kritisch bearbeitet von Karl Koch. Erster Theil. Erlangen. Enke, 1869.

and the gardener have it in their power to naturalise plants foreign to our climate and our soil.

But the conditions of this naturalisation are by no means so simple as might at first sight appear. It might naturally be supposed that all we have to do is to introduce those plants which grow spontaneously in a climate and a soil similar to our own, and that they will necessarily flourish, and will scarcely be aware of the change. Or, if they come from a warmer country, that all that is needed is to protect them by glass and artificial warmth from the inclemency of our winters. But in practice this is not found to be the case. A plant will frequently obstinately refuse to become naturalised in a country, the climatal and geological conditions of which are similar to those that occur in the region where it is indigenous. Our common daisy, a native of almost every country of Europe, is said to have resisted all attempts to introduce it even into the gardens of the United States. Some plants seem to have an unconquerable aversion to the fostering hand of man, even in their own country. A well-constructed and carefully-kept fernery will contain specimens, more or less luxuriant, of nearly all our native ferns; the polypody and hartstongue from shady banks and tree-stumps; the so-called male and female ferns from the woods; the spleenwort from dry walls; even the royal "flowering-fern" from bogs; and some of the semi-alpine species will flourish with the exercise of a little care. One kind, however, is almost invariably absent, and that the most widely distributed of all our ferns, the common brake, a native of every county and almost of every parish in the country, but which can seldom be induced to remain a denizen of soil that has once been brought under man's dominion. On the other hand, some of the greatest favourites of our gardens, which display no coyness whatever in overrunning our flower-beds, are natives of countries where the climate presents very different features to our own, or of very limited tracts of our own country, to which they seem strictly confined by impassable barriers of soil or meteorological conditions. To take instances of the latter phenomenon:—There is no garden flower more cosmopolitan in its tastes, more certain to thrive under any conditions of light or heavy soil, sun or shade, care or neglect, even in the heart of a town, as its very name seems to indicate, than the London Pride. Yet the *Saxifraga umbrosa* is one of the most restricted in distribution of our native plants. Abundant enough where it does grow, it is yet entirely confined to the moist equable climate of the hilly country in the south-west of Ireland and a few other similar localities, beyond which it is never found in the wild state. Botanists will think themselves amply repaid for a toilsome day's march by gathering the beautiful *Polemonium cæruleum* in its native habitat among the calcareous hills of the west of Yorkshire; yet the Jacob's Ladder is an ornament of every garden on the very

stiffest part of the London clay. Probably every piece of cultivated ground, which contains a laburnum tree, produces each spring a plentiful crop of self-sown young trees, which come up without the least care or protection until destroyed in the process of weeding; yet the laburnum shows no disposition to take a place among the naturalised trees of our woods and hedges, although the seeds must often be carried there by birds. It is remarkable that many of our common vegetables, the cabbage, the asparagus, the sea-kale, the celery, are natives of our own shores, never growing spontaneously out of reach of the salt spray; and yet requiring, when transplanted into our gardens, no peculiarity of soil or treatment to enable them to support a vigorous existence. These are instances of plants to which our climate appears entirely congenial, and yet which seem as if they could not propagate themselves with us or spread, except under man's protection. Others, again, appear to require only to get a footing in a foreign soil to become established in it with extraordinary rapidity, even to the overmastering or expulsion of some of the indigenous inhabitants. When Australia and New Zealand were first colonized by Europeans, their flora presented an aspect of perfect strangeness, very few of the native trees or flowers belonging even to genera common to Europe. The seeds of some of our English weeds were, however, introduced, intentionally or accidentally, by the early settlers; and now the thistle covers the waste lands of Australia as it does in England, and the clover and the groundsel everywhere remind the Englishman of his far-away home, and have become as completely at home as the mustangs or wild-horses on the pampas of South America. In our own country a very remarkable instance of this rapid naturalisation has occurred in the case of the *Elodea canadensis* or Canadian water-weed; which, introduced not many years since into our canals from Canada, has now become such a pest in many places as seriously to impede the navigation. Other instances might be mentioned of foreign plants introduced with seed having in a very short time become common weeds in all cultivated land. Indeed, many of the species included in our handbooks of British plants are so entirely confined to arable land or to spots in the immediate vicinity of human dwellings, that it is impossible to say how many of them may be really indigenous to the soil, and how many naturalised aliens.

There is no doubt we have a great deal to learn as to the mode in which plants propagate themselves in nature, which may be of the utmost value to our gardeners. Every one is familiar with the fact of the apparently spontaneous appearance, in immense abundance, of plants in soil when subjected to certain farming operations, or on the sowing of some particular crop. Whenever a new railway cutting or embankment is made, some plant unknown in the neighbourhood is almost sure to appear, and either permanently

establish itself or again disappear after a few years. The "sowing" of land with lime is invariably followed by the appearance of a crop of white or Dutch clover. When certain kinds of wood are cut down, it is said that during the next year a particular species of moss will always be found covering the ground. Immediately after the great fire of London in 1666, the London Rocket (*Sisymbrium Irio*) sprang up in enormous quantities on the dismantled walls, but is now no longer to be found in the metropolitan district. The usual theory to account for this sudden appearance of new plants is the existence in the soil of large "stores of seeds" ready to germinate on the first favourable opportunity. In his Anniversary Address to the Linnean Society in 1869, Mr. Bentham, however, pointed out that if this explanation is the true one, it ought not to depend merely on theory, but would be capable of easy practical verification. He suggested whether a hitherto insufficiently acknowledged part in the rapid dissemination of plants may not be played by birds. The whole subject presents a wide field for further investigation, and must amply reward any one who takes up the inquiry, if endowed with the qualities of accurate observation and patient research.

Mr. Mongredien's 'Planter's Guide' deals chiefly with the introduction into this country of foreign trees and shrubs. Within the last twenty or thirty years the appearance of our lawns and plantations has been greatly changed by the number of new forms which have made their appearance. The stately *Wellingtonia*, the formal self-asserting "Puzzle-monkey" or *Araucaria imbricata*, the massive Deodar and *Cryptomeria*, the elegant *Pinus insignis* and *Cupressus Lawsoniana*, are all still of too recent introduction to permit us to judge of what their effect will be when grown to their full stature. The number of cone-bearing trees from all parts of the world, perfectly hardy in this climate, is extraordinary; and, partly from their graceful shape, partly from the evergreen character of their leaves, the attention of cultivators has been perhaps too exclusively confined to them, while deciduous trees have been comparatively neglected. Recent experiments have shown that in this quarter also there is abundant room for an extension of our powers of domestication. In one of the London Parks least frequented by the upper ten thousand, that at Battersea, great success has attended the introduction, during the last few years, of half-hardy trees and shrubs, the precaution being taken of protecting their roots during winter by a layer of some substance impervious to frost. The French have paid more attention to the perfect naturalisation of half-hardy plants than we have done: notwithstanding the greater severity of their winter, species are grown by them out of doors which are never seen with us except in greenhouses; even as far north as Paris, the bamboo, for instance, is frequently met with in

gentlemen's gardens; and there is no doubt that many shrubs and herbaceous plants, which we never think of attempting to grow except under protection, might, with a very little care and attention, become permanent denizens of our gardens and shrubberies. Probably few are aware that the common Camellia will stand with impunity an ordinary English winter. Mr. Mongredien says that "if protected during the first two or three years after being planted out, and when once established, it proves in the climate of London quite as hardy as the common laurel, and blooms as profusely as in a conservatory. It is true that, from its habit of flowering early in the spring, the blossoms are sometimes damaged by the nipping easterly winds, but this occurs only in unfavourable seasons; and even if the tree never flowered at all, its lovely foliage would still make it one of the most beautiful evergreens of which our gardens can boast. A plant of the variety *Donkelarii* has stood out for twelve years in a garden at Forest Hill with a northern aspect, without the slightest protection during the severest winters, and now forms a good-sized bush, densely clothed with magnificent foliage. The Camellia ought to be planted out in every garden, and with a little attention for the first year or two, it would prove quite hardy, at least in the more southern counties, and each season it would increase in attractiveness."

The climate of the south of England is far more congenial to the introduction of foreign trees and shrubs than that of the northern counties, not from the greater severity of the winters in the north, for the minimum temperature of the year is often as low in Kent or Hampshire as in Yorkshire or Northumberland, but from the shorter and cooler summers. Many plants absolutely require a considerable period of high temperature to enable them to ripen their wood sufficiently to withstand the winter frosts, and especially to induce them to flower. In many parts of Scotland, however, the climate is as favourable to horticulturists as in any district of England. In the Duke of Sutherland's estate at Dunrobin, on the east coast of Sutherlandshire, Hydrangeas, myrtles, and other half-hardy plants, grow as freely and as unchecked out of doors as they do in Devonshire or Cornwall. The equalizing effect of the Gulf Stream on the temperature is no doubt the cause of this special immunity from frost. The proximity of the seacoast is not generally favourable to the growth of trees and shrubs, not so much from the saltness of the air as from the prevalence of high winds, which are very injurious to growing vegetation. Young and tender shoots which will bear a moderate amount of cold, will sometimes be scorched as if by fire by a tempestuous night.

Mr. Mongredien's book is intended as a repertorium of everything connected with the choosing, planting, and treatment of English and foreign trees and shrubs, and contains an immense mass

of information for any one whose tastes lie in this direction. Its defects are rather of omission than of commission. The plan promises a completely exhaustive treatment of the subject: in the first place we have an alphabetical list, with brief descriptions, of 621 trees and shrubs, selected as desirable for planting in the open air in this country; followed by a classification of them under a variety of headings, as to their height, their foliage, their time of flowering, the colour of their flowers, their fruit, their timber, and other points. It is illustrated by a number of very pretty woodcuts, of which we subjoin a specimen. The principle on which these 621 species

Abies nobilis; Wimbledon.

have been selected is not always obvious. Why, for instance, is our common Fuchsia (miscalled *Fuchsia coccinea*, as Dr. Hooker has shown) excluded, forming as it does the glory of every cottage-garden in the Isle of Wight and in Devonshire, the stems assuming almost

a tree-like character; or the *Berberis aquifolium*, which, with its glossy leaves and very early flowers, is so deservedly a favourite in every shrubbery? In the enumeration of winter-flowering plants we miss also the beautiful *Forsythia*, and several others which might have been mentioned. An exceedingly useful list is that of "species which thrive in the smoke of cities," in which Mr. Mongredien names the horse-chestnut, *Ailantus glandulosa*, Virginian creeper, almond, *Artemisia abrotanum*, Aucuba, Catalpa, *Cydonia japonica*, laburnum, fig, ivy, Cape jasmine, privet, *Paulownia imperialis*, *Phillyrea media*, plane, evergreen oak, *Rhamnus Alaternus*, sumach, flowering currant, *Robinia pseudacacia* (commonly called the acacia), *Sophora japonica*, and guelder rose; a very useful list to cultivators of suburban gardens, but again very incomplete. In London gardens the lilac is everywhere the companion of the laburnum; magnificent hawthorn-trees could be shown within two miles of Charing Cross; the roads in the suburbs are everywhere adorned in early spring with the beautiful light-green foliage of the lime; while the sides of the houses are gay in the summer with the gorgeous flowers of the hardy passion-flower, or the gigantic leaves of the *Aristolochia Sipho*; nor should the apple, the pear, and the cherry have been omitted, if it is only for the wealth of their flowers. It is worthy of remark that the smoke of an ordinary town is not nearly so destructive to vegetation as that poured forth from the chimneys of manufactories or chemical works. Flowers will be found to thrive in gardens in the very heart of London, which many a Lancashire gentleman would give almost any money to establish even in his greenhouses. Notwithstanding the deficiencies we have named, 'The Planter's Guide' is a book that should be in the hands of every one interested in the subject; and we hope it may be the means of attracting attention to the great value and importance of ornamental planting in improving the character of our lawns, shrubberies, and parks.

If we now turn from trees and shrubs to herbaceous plants, we enter on a still wider field, and one more within the reach of every lover of nature. Arboriculture, after all, must always be the pursuit of those only who have both money and space at their command; floriculture may be followed by every cottager, and even by every dweller in a town who has a window-sill at his disposal; and we doubt whether the latter does not derive the most pleasure from it. Although many of the favourite flowers of the last two or three generations will probably always hold a place in our gardens, and deservedly, yet the number of species that have been introduced of late years worth cultivating for their beauty, and within the reach of every one who possesses a flower-pot, is very large; and as a hand-book for this class of plants, though treating only of a section of them, plants especially adapted for rock-work, we can most

cordially recommend Mr. Robinson's 'Alpine Flowers for English Gardens.' The easy and lively style in which it is written, no less than the excellence of its matter, will commend it to every lover of plants.

Mr. Robinson is no mere enthusiast in his subject when he says:—"This book is written to dispel a very general error, that the exquisite flowers of alpine countries cannot be grown in gardens, and as one of a series of manuals having for their object the improvement of our out-door gardening, which, it appears to me, is of infinitely greater importance than anything that can ever be accomplished in enclosed structures, even if glass sheds or glass palaces were within the reach of all." His first concern is with the structure of rockeries, in the mode of building which not only is the taste still displayed, or at all events till quite recently, barbarous and inartistic in the extreme; but it would seem as if the very conditions necessary for the health of the plants were studiously neglected. The ordinary idea of the treatment of rock-plants, judging from the hideous monstrosities which may be seen in many a gentleman's garden, is that you have nothing to do but to poke them in between the chinks of perfectly bare stones or clinkers piled together in a promiscuous heap, in order to present them in their native habitats. A gardener who commits such an absurdity as this, can never have ascended a mountain with his eyes open. To quote again from Mr. Robinson:—"Mountains are often bare, and cliffs are usually devoid of soil; but we must not conclude therefrom that the choice jewellery of plant-life scattered over the ribs of the mountain, or the interstices of the crag, live upon little more than the mountain air and the melting snow! Where will you find such a depth of well-ground stony soil, and withal such perfect drainage, as on the ridges of *débris* flanking some great glacier, stained all over with tufts of crimson saxifrage? Can you gauge the depth of that narrow chink, from which peep tufts of the diminutive and beautiful *Androsace helvetica?* No; it has gathered the crumbling grit and scanty soil for ages and ages; and the roots enter so far that nothing the tourist carries with him can bring out enough of them to enable the plant to live elsewhere." Alpine plants are peculiarly exposed to sudden alternations of heat and cold, of moisture and dryness. The cold, almost frosty night will be followed, in July and August, by an unclouded day, when the rays of the sun beat on the unsheltered surface of the rock with an intensity that would scorch up many an English meadow plant. Only a very small proportion of alpine plants are annuals; and they are frequently provided with a storehouse of nourishment in the form of rosettes or tufts of thick succulent leaves; but their chief water-supply is through their roots; and thus we find that while our garden annuals have fibrous roots of insignificant dimensions, and even

our forest trees will seldom strike their roots to a greater depth than the height of their foliage, the roots of alpine plants scarcely an inch in height will be found to penetrate the chinks between the rocks full of rich earth, to the depth of sometimes more than a yard, or forty times the height that they venture into the air. The neglect of this most essential condition for the growth of alpine plants is of itself amply sufficient to account for the failure which has generally accompanied the attempts to introduce these lovely flowers to our rockeries. A good depth of soil is indeed more indispensable to these plants than the presence of rock and stone. They no doubt prefer to expand their flowers and extend their green shoots over the bare rock; and where rock-work is artistically managed, this faint attempt at a reconstruction of their native habitat adds greatly to the picturesqueness of the effect. But many of them will flourish equally well in open borders, and even when planted in pots, with a few stones about them to protect the roots from the direct action of the sun, if only the two requisites are attended to, of constant moisture and perfect drainage; and hence they are invaluable acquisitions to the cottage or window gardener. The Saxifrages, the beautiful purple *Aubrietia*, with respect to which Mr. Robinson says, "rock-works, ruins, stony places, sloping banks, and rootwork suit it perfectly; no plant is so easily established in such places, nor will any other alpine plant clothe them so quickly with the desired vegetation," the various species of Arabis, the alpine Primulas, all make excellent bedding plants. The ease with which a new alpine can be domesticated in our climate is shown by the rapid spread of the lovely early forget-me-not, *Myosotis dissitiflora*, brought not many years since from the Alps near the Vogelberg, now to be had from every nurseryman, and the treasure of many a cottage garden, with its exquisite sky-blue flowers, continuing from mid-winter till early summer.

But it is not alpine flowers only which will repay the small amount of trouble necessary for their introduction. Many plants which are never grown without the protection of a greenhouse, do not require any elevation of temperature for their successful growth, but merely an absence of great changes both of temperature and moisture. This is especially the case with not a few of the most delicate ferns, such as the elegant maidenhair, and the two fragile little filmy-ferns; and the requisite uniformity of temperature and moisture can be obtained out of doors by the erection of a partially underground grotto or ravine of rocks, through which water is perpetually trickling, the entrance being protected by a screen of foliage from the direct influence of the weather. It is astonishing how equable a climate can be obtained by a simple device of this kind. The drawing given on p. 359 is from such a rock-cave constructed in the grounds of one of our most scientific and success-

ful nurserymen near York, where he grows not only our royal so-called "flowering fern," the *Osmunda regalis*, and several foreign

Entrance to Cave for Killarney Fern in Rock-garden.

allied species, but the most beautiful of all this beautiful tribe, the moisture-loving Killarney fern, which clothes the soil of the damp dark woods by the Torc waterfall.

The beauty of these horticultural experiments is that they can be tried on so small a scale, and are thus within the reach of almost every one; yielding a source of pure and healthy enjoyment which few other pursuits will afford. Mr. Robinson almost promises us that his little book shall be the first of a series of similar manuals on different departments of gardening; and we can hardly conceive a greater service than this to a large number of his countrymen, who merely require to be told how to set to work to cultivate this fascinating science.

VII. A RECENT TRIUMPH OF SYNTHETICAL CHEMISTRY.

It is not often that so legitimate a triumph of synthetical chemistry as the artificial production of a natural substance becomes, at the same time, an important national discovery, the money value of which may be reckoned by millions. Such, without exaggeration, it is not unlikely that the artificial production of Alizarine, the colouring matter of madder, may become.

Madder is the root of a plant belonging to the order of *Rubiaceæ*, amongst which are included some valuable plants, such as the cinchona, ipecacuanha, and coffee. The madder plant is the *rubia tinctorum*. It is estimated that its consumption reaches over 47,000 tons per annum, and this, at 45*l*. per ton, amounts to over 2,000,000*l*. sterling, one half of which is imported to England, and the payment for which (1,000,000*l*.) goes out of this country into the pockets of foreign manufacturers. If now the essential constituent for which madder is so valuable, its pure colouring matter, can be economically prepared by chemical means from coal-tar, that amount of money will naturally go into our own pockets—a not unworthy reward for chemical ingenuity.

The value of madder in dyeing and calico printing depends upon the many different colours which can be dyed by its means; thus, one mordant (iron) gives purple shades, from the most delicate mauve to black; with another mordant (alumina), red shades are produced, from the palest pink to deep crimson, including the brilliant and well-known Turkey red; and by judicious admixture of these mordants, combinations of all varieties of chocolate-brown are produced. These colours are very permanent, whilst the high price of the raw material to which they are due renders the discovery of a substitute a problem of the highest commercial importance. For these reasons the chemical investigations of madder have been very numerous, the most valuable results having been obtained by our own countryman, Dr. Schunck. This chemist found that the root did not contain a colouring matter ready formed, but there was in it, amongst many other bodies, a crystalline substance, which he named *rubianic acid*. When the powdered madder is allowed to stand in a moist state, or is gently heated with water in the dye-beck, a peculiar fermentation sets up under the influence of a ferment called erythrozyn, by which the rubianic acid is split up into alizarine and glucose. Besides alizarine, there is another colouring matter obtained from madder, called purpurine; but as all the valuable shades and colours of madder are due to the alizarine, we need only devote attention to the latter substance.

Alizarine is a brilliant scarlet substance, which crystallizes in

prisms, and when exposed to carefully-regulated heat, sublimes, condensing into beautiful tufts of scarlet needles; it is only sparingly soluble in water, but dissolves in spirit, and in alkaline solutions; its tinctorial power is at least thirty-five times as great as that of madder itself. Dr. Schunck was the first to point out that Turkey red, madder pink, and all the finer madder colours, are simply compounds of alizarine and fatty acids with bases, and he has described a process for preparing pure alizarine from cotton which has been dyed Turkey red.

The discovery of the method of preparing alizarine artificially is due to two continental chemists, Messrs. Graebe and Liebermann, and their discovery is the more remarkable, since it has not been effected by any haphazard, rule-of-thumb system of experimentation, but is the result of a scientific investigation on the properties and molecular structure of alizarine, and has been conducted, step by step, in accordance with logical deductions from the known laws of synthetical chemistry. The train of reasoning is too complicated, and requires too profound a knowledge of the laws of modern chemistry, to be given in detail here, but a brief outline of their research will perhaps be of interest.

From an examination of the substances obtained when pure alizarine from madder was submitted to sundry chemical processes, it was ascertained that this principle was connected with the hydrocarbon group containing fourteen atoms of carbon, and by heating it with a body capable of removing oxygen, they obtained from it the hydro-carbon of the group, containing fourteen atoms of carbon and ten of hydrogen. This was seen to be identical with one of the solid crystalline bodies obtained in the distillation of coal, named anthracene; and by a somewhat complicated process they converted this into anthraquinone, then into bibrom-anthraquinone, and lastly, into alizarine; having by this means added four atoms of oxygen to and removed two atoms of hydrogen from the alizarine. The key to the synthetical formation of alizarine having thus been discovered, it was not long before improvements were effected; for when a particular series of chemical reactions have to be performed, a clever chemist can always find different ways of effecting them, as the records of many a celebrated patent case will show. There are now four processes in operation, three of which are patented, whilst one is being worked secretly. All effect the same purpose by somewhat similar means, but by the use of different reagents, and all start from anthracene. Mr. Perkin's patent is now in operation in this country, and his artificial alizarine is in use amongst the Scotch dyers, where it is competing favourably with madder. Besides alizarine, other colouring matters are formed during these synthetical operations; and unless care is taken in the purification, the tones produced by the artificial colouring matter are liable to be somewhat yellowish;

but when pure, there is no doubt as to the identity of the artificial and natural dyes, as they are similar in their absorption spectra, their tinctorial powers, their unalterability under the influence of light, and their solubility.

Whether artificial alizarine will supersede madder to any great extent depends principally on the supply of the raw material, anthracene. Dr. Roscoe says that in an experiment made on a large scale it was found that 100 tons of tar yielded 0·63 ton of anthracene, or 1 ton of anthracene could be obtained from the distillation of about 2000 tons of coal, not reckoning the quantity of anthracene contained in the pitch. But tar distillers have hitherto turned very little attention to this substance, and from some experiments of Mr. Perkin it is probable that some kinds of coal-tar contain considerable quantities of anthracene. Attention being now directed to the subject, all experience tells us that the demand will bring a supply, and already we see signs of this in the advertisement pages of chemical periodicals, where the price of anthracene is regularly quoted along with that of other coal-tar products. Should our anticipations be fulfilled, this discovery, although made by German chemists, cannot fail to be of most benefit to England, the great tar-producing country of the world. Tar distillers will do well to bear this in mind, and examine the influence of various temperatures in distillation, for anthracene is likely to become as important as benzol was a few years ago.

W. C.

NOTICES OF SCIENTIFIC WORKS.

FORMS OF ANIMAL LIFE.*

Twenty years ago a number of statutes were passed in the University of Oxford indicative of a commencing change in the educational methods pursued at that venerable institution, of which change the book before us is one of the fruits. The "progressive studies," and prominently among them the study of the natural sciences, were introduced as legitimate objects of pursuit; and the admission thus made that, in the opinion of some, they were at least competent to supplement, if not to supplant, as agents of intellectual discipline, the investigation of the ancient classics, or of the philosophical works of Kant and Hamilton.

Whether science, however, as distinct from literature, be efficient in developing the mental faculties and engendering correct habits of thought, must depend entirely on the method in which it is pursued. It must be obvious to anyone who has had much experience in teaching, that it is quite as easy—and perhaps even easier—for a youth to acquire a scientific as a classical pedantry; to be able glibly to talk chemistry, as many boys do their Latin, by employing a confused jumble of words and formulæ, without the slightest appreciation of broad general principles. It is, indeed, quite marvellous how little has been effected in England in some branches of science, even under circumstances that would at first sight appear most favourable, merely through the pursuit of a wrong method. Ask ninety-nine out of a hundred senior medical students what the effect of a section of the phrenic or the sympathetic nerve would be, and they will probably detail certain characteristic changes in the respiration and circulation. Supplement the first question by another requiring the source of their information, and they will at once give the name of the compiler of the physiological text-book most in vogue at the time. Now ask two similar questions concerning the situations of these nerves in the human body, and the replies will be of a very different character. Their directions and relations to contiguous parts will be promply set forth; and in reply to the second query the students will inform you that they have seen the nerves with their own eyes, and dissected them with their own scalpels, and are quite prepared to prove the correctness of their statements by a demonstration of

* 'Forms of Animal Life: being Outlines of Zoological Classification based upon Anatomical Investigation, and Illustrated by Descriptions of Specimens and of Figures.' By George Rolleston, D.M., F.R.S., Linacre Professor of Anatomy and Physiology in the University of Oxford. Oxford: Clarendon Press.

them in the anatomical theatre. In the first case the knowledge is hearsay, in the second it is the result of close individual observation, and is therefore real.

Now it is the acquisition of a real and substantial basis of facts —facts which must be verified again and again by the observing eye and sensitive touch—to which physical and biological science, as an engine of education, should first prompt the student. In other studies words come to him invested with the authority conferred by the name of some master. In these he is to believe what he sees and can prove by experiment.

If it be asked why two such nearly related subjects as Anatomy and Physiology should be studied so differently, and with such different results, we think the answer is near at hand. Comparative anatomy, as a branch of scientific education, has, until recently, been almost entirely neglected, and even now is not extensively taught. Comparative physiology cannot be studied without a preliminary groundwork of comparative anatomy. While, thirdly, almost all advance in human physiology must depend on experiments made on the lower animals. In these three statements we have indicated what we conceive to be the true answer. Students cannot themselves work out the physiological problems connected with the nerves in question, or any other similar part, because they are not sufficiently familiar with their relative position in the only bodies on which experiment is possible, *viz.* those of the lower animals. When a course of comparative anatomy, carried out not merely by dry lectures, but by actual dissections and demonstrations on familiar representative animals, be considered an integral part of a medical education, and not till then, will physiology be generally studied according to a better method.

But if an English student of medicine of to-day desires to fit himself for pursuing physiological studies after the manner indicated, or by practical dissection to enlarge his knowledge of those empirical laws which underlie animal forms, whither is he to look for a guide —such a guide as books on anthropotomy afford him in his practical study of the human body? Except the book before us, we do not know any that would serve his purpose. There are many books of great value which give the results of comparative anatomy; as, for example, Professor Owen's great work; or the remarkably lucid and able 'Introduction to the Classification of Animals,' by Professor Huxley. But their scope and aim are different. Professor Rolleston's book does then, we think, supply a real want.

By the aid of its very clear descriptions, and, if possible, still clearer figures, the student is enabled to dissect and recognize all the salient points in the anatomy of a rat, pigeon, frog, and many another familiar and typical animal. The volume is not intended for the mere reader of comparative anatomy, and will do him no good—

or at least no more good than any other able treatise on the subject. It is designed as an aid to the practical worker; not to burden his memory and confirm him in the enervating habit of receiving on trust statements which ought to be verified by observation, but to educate him into the way of educating himself. Though written primarily for the benefit of students of the University of Oxford, in the museum of which institution an illustrative series of preparations exists, we think we have said enough already to prove that its advantages need by no means be limited to them; but that it will prove most useful to all those who desire, like we did in our own student days, a reliable guide by which to work. To go through the book as the author designs it to be gone through, and as the reader for his own sake should make up his mind to go through it, will involve both time and labour; but they will be time and labour well expended.

There are three parts to the work. First, an introduction, "giving a classification of the animal kingdom, with a zootomical account of the various sub-kingdoms and their subordinate divisions and classes." Secondly, a "description of certain readily procurable specimens, which illustrate in the concrete a very large number of the systematic descriptions contained in the introduction;" and thirdly, descriptions of figures supplementary to the descriptions of specimens, and designed to aid those specimens in "furnishing that groundwork of particular facts, without which it is impossible to obtain any real knowledge or permanent hold of general principles." This endeavour to erect the principles of the science on a firm basis of fact, which the student is taught how to observe for himself, is the unique and most valuable feature of the book.

Of the three parts, the first consists of 168 pages, and is recommended in the preface to be studied after the preparations and specimens whose descriptions succeed it. We do not quite see, as these are to be read first (as they undoubtedly should be, and that too as a commentary on actual specimens; all the better if actually made by the reader), why they should be placed second. This is a matter of small moment perhaps, except that a book is generally written in the order in which it is intended to be read; and that a good many people either pass over prefaces altogether, or read them just as authors write them, namely, after they have finished the works to which they are intended to be the real introductions. One of the most striking features of this first part is its extreme truthfulness. No attempt is made to construct a completer system than Nature herself has given. Everything in it is reliable, because in everything Nature has been followed, not led. Nothing is easier than to fix on some one character as a basis, on which a zoological system can be constructed, whose symmetry and philosophic completeness shall captivate the mere reader of zoology—nothing, except the readiness

with which this symmetry can be shown to be unreal. We could point to more than one book, whose numerous editions testify to their numerous readers, written on this principle. In the "Introduction" before us, if we miss a little of the charm of a completeness, easily attained when men construct animal kingdoms out of their own imaginings, we recognize in every page the far more substantial advantage of a severely conscientious truthfulness. Scarcely a fact of broad and general application is stated, that has not the "but," which introduces all the exceptions to it, immediately after; and it will be a great satisfaction to the student of the book to know that, however much he may have to supplement the knowledge it affords him as the science of comparative anatomy may advance, he will have little or nothing to unlearn.

The admirable calmness and temper displayed when the passing discussion of any biological theory is rendered necessary; the carefulness with which conclusions which are merely probable are distinguished from others that bear the stamp of certainty; the evenness with which the balance is held between opposing probabilities—as for example at pp. xxv. and clxii. respectively, where the theories of evolution and of the existence of a *regnum protisticum* are reviewed; and the readiness everywhere manifested to accept any new truth when proved, coupled with a cautiousness in disparaging the old simply because it is so, cannot fail to exercise a wholesome influence on the mind of the reader.

In two ways we venture to think the value of this part might be enhanced. First, by the addition to it of some such glossary as that appended by Dr. Pye Smith to Professor Huxley's "Introduction." Secondly, by the devotion of a single figure and about a page of description to the elucidation of the constituent parts of a complete vertebra; in the absence of which the student is referred, at p. 9, Part II., to Professor Owen's 'Descriptive Catalogue,' a work not easily obtained, except by those living in Metropolitan or University towns.

The second part consists of the descriptions of fifty preparations obtained from representative, and for the most part easily procurable animals, such as the rat, pigeon, common fowl, frog, perch, crayfish, &c. While they are so clear as to enable the student easily to recognize in the preparation before him its anatomical details, or to make the preparation for himself if he has not access to a museum containing it, they are something more than mere descriptive sketches of the particular animals under consideration. Each serves as a text for a discourse on the entire class, and side by side with the account of every organ are allusions to homologous organs of creatures in allied orders. With the descriptive anatomy of the common crayfish, for example, are frequent comparisons of its different parts with those of other Decapods, both brachyurous and macrourous; of Iso-

pods, Amphiopods, and many others; so that by being thus grouped around one central and familiar figure, the resemblances and differences can be better appreciated and more easily remembered.

In the third part are twelve plates containing drawings of nine dissections of common animals, executed from the dissections themselves, by Mr. G. Crozier, formerly draughtsman to the Radcliffe Library, Oxford; and sixteen diagrams taken from the best sources. In the descriptions, which serve as comments on these figures, there is necessarily at times some amount of repetition of what has been gone over in the previous part. Nobody, however, who knows how much the impressions of facts upon the mind are deepened by their being presented in different manners, will regret this. The facts of anatomy, as every teacher or learner of it knows, have to be reiterated many times before they become retained.

A certain amount of preliminary knowledge is necessary before this book, or indeed before any book on comparative anatomy, can be beneficially studied. It is not much. One session's steady work will give any average student a fair knowledge of human osteology and visceral anatomy, and then he will be prepared to enter with advantage on such a study of comparative anatomy as Professor Rolleston has here so admirably sketched out for him.

OTHER WORLDS THAN OURS.*

The first sentiment of a thoughtful man untrammelled by the influences of doctrinal theology, when he hears the question, "Are the celestial spheres intended as the abode of life?" is one of profound astonishment. The more natural inquiry, it seems to him, would be, "Why should the other worlds not be the seats of living organisms?" and the very question reminds him at once of the littleness of his race, and of the restricted mental capacity which can seriously entertain such a doubt. Imagine a colony of ants, who have raised, what appears to them, a vast monument of their enterprise and industry in the shape of a little mound, upon some islet in a vast lake; and conceive of the complacency with which the ant-philosophers will gaze upon the neighbouring islets, from which they are separated by an impassable barrier, and of their grave deliberations as to whether those other vast regions are peopled with beings like themselves, or what can have been the object Nature had in view when she raised up other lands besides their own? This is precisely the position of our philosophers who cling to the idea that

* 'Other Worlds than Ours: the Plurality of Worlds studied under the Light of Recent Scientific Researches.' By Richard A. Proctor, B.A., F.R.A.S. Longmans, Green, & Co.

ours is the only habitable world, and that the rest are but shining lights placed in the heavens to give us light by night.

If we thought that many of our readers continued to hold this doctrine, we should indeed lay down our pen in despair, and descend to themes which come within the scope of the utilitarian understanding; but thanks to the rapidly advancing strides of science, we may fairly assume that a large proportion of the readers who consult these pages are quite prepared to consider with the author of the work before us, not whether other worlds are the seats of organized existence, but whether we have any, and, if any, what kind of evidence concerning the nature of the living forms which now inhabit, or are destined in future to reside upon, the other celestial spheres.

In considering the question from this point of view, we are compelled still to admit our profound ignorance; but we may do so without shame or humiliation, for in this case it is no longer the unreasoning ignorance of the lower animals—we are no longer ant-philosophers—it is the darkness which precedes light; the gloom that is being dispelled, slowly but surely, by the efforts of philosophical research, through that quality of the human mind which distinguishes us from inferior intelligences. We know very little indeed of the conditions of existence in spheres other than our own, and although Mr. Proctor has managed to write a book of more than 300 pages on the subject (a great portion of which, however, deals with matters interesting enough in themselves, but completely alien to the main inquiry), all that has been ascertained with anything approaching to certainty as bearing upon the habitability of the heavenly bodies, might easily be compressed into a dozen sentences. So that if we were strictly to obey the injunction which is given to young lawyers, that before they begin to consider the law in any particular case upon which they are consulted, they should thoroughly master the facts; if, we say, we were to apply this safe method to the question, what kind of beings are living or destined to live upon the heavenly spheres, the consideration of the subject might be long deferred, and we should have to pronounce upon it with great doubt and hesitancy.

Around Mercury there is probably some kind of atmosphere, but the planet is too near the sun to admit of a satisfactory examination with our present philosophical instruments. Venus almost certainly possesses an atmosphere, and the inclination of her axis leads us to infer the existence of seasons.

Mars is the great *pièce de résistance* in this light intellectual banquet. That planet has almost certainly an atmosphere heavily laden with clouds, two poles similar to our own, capped with snow which encroaches upon and recedes from its more temperate zones according to the seasons of the Martial year of 687 days; those seasons being, like our own, the consequence of an inclination in

the axis of the planet to its orbit. But our information concerning Mars does not stop here, for astronomers are sufficiently convinced of the existence on its surface, of continents, islands, oceans, seas, straits, and inlets, to have given them such designations as W. Herschel Continent; Kepler, Lockyer, &c., Lands; Phillips Island; Dawes Ocean; De la Rue Sea; J. Herschel Strait; Nasmyth Inlet, &c., as may be seen from Mr. Proctor's interesting chart in the work under review; and if these surmises be correct—if the fair face of Mars is divided into land and water, and if its skies are varied with clouds and sunshine, it is only a reasonable inference that in every other respect its physical aspect resembles that of our own earth; its continents being diversified by hill and dale, plain and valley; its valleys adorned with lakes, and serving as the beds of rivers; whilst waterfalls will likely adorn its hill sides, and glaciers its mountain recesses. And if so, *cui bono?* Are there no trees and shrubs to draw their nourishment from its streams and watercourses? no insects nor other flying things to flutter in its sunshine? no living, moving beings to wander over its vast continents? And if some of these should still be absent, has all this beauty been produced in vain *for ever?* We leave the common sense of our readers to dictate the answer, for they are as well able to form an opinion on the matter as the author of the work before us.

From the slight inclination of its axis, Jupiter has no seasons in the ordinary acceptation of the term, but probably the planet possesses a cloud-laden vapour with its consequences. It is possible that Jupiter may be in a condition somewhat similar to that in which our earth was when its seas swarmed with ancient forms of life. Mr. Proctor does not say so, but judging from the necessity of a supporting medium for its animal races (if it possess any), in consequence of their additional weight as compared with those on the earth's surface, as will be explained presently, and from other circumstances, such a view is worth consideration. Saturn, too, has probably an atmosphere laden with vapours; and here our knowledge, which can hardly be called positive, of the phenomena favouring the existence of life in other parts of our Solar system, terminates.

There are, on the other hand, certain well-established phenomena which render life impossible upon certain other spheres. The photosphere of the Sun consists probably of glowing vapours, amongst which those of many well-known elements, such as iron, calcium, magnesium, as well as hydrogen gas, have been distinctly traced by spectrum analysis; and so, too, similar elements in the same form, sodium, magnesium, iron, hydrogen, have been clearly ascertained to exist in some of the fixed stars.* In such an atmosphere, it is

* See Huggins "On Recent Spectroscopic Researches," 'Quarterly Journal of Science,' April, 1869.

safe to say that no beings at all resembling those which live on earth could possibly exist. Again, that side of the moon which is visible to us has, in all probability, neither atmosphere nor water, and it is subjected to the unimpeded action of the sun's rays for the space of fourteen days without intermission, a protracted tropical day, which is followed by an Arctic night of equal duration. Although there are grounds for believing that in past æons our satellite may have been the abode of life, it is hardly possible, for the reasons named, that it can be so in our time.

Again, there are circumstances from which it may reasonably be inferred that even where it is legitimate to assume the existence of living creatures on certain orbs, they must be constituted differently from those we know on our globe. For example, an object which on the earth's surface weighs 1 lb., weighs only 7 oz. on Mercury, but the same object would weigh 2½ lbs. on Jupiter; so that a man of 10 stone here would have to carry 25 stone on Jupiter, and only 4 st. 6 lbs. on Mercury; and Mr. Proctor, if he had wished to indulge his lively imagination more freely than he has done, might have conceived of Mercury as an advanced planet, peopled by a superior race of beings, who having a lighter weight to carry and consequently less need for muscular exertion, would probably require only one meal a day to compensate for physical waste, and would therefore have more time and energy to devote to higher occupations than mere nutrition. And, as already mentioned, the additional weight which creatures would have to carry on Jupiter, with its present size and density, suggests the idea of its containing vast seas, that support Ichthyosaurs and their congeners. These are, of course, speculations, like Mr. Proctor's; but it may be as well to mention that on all matters involving biological as well as physical considerations, even speculators should be conversant with the past history of life on our earth; should be geologists and palæontologists as well as physical and astronomical observers. The more we study Nature as a whole, the greater the need appears for a school of thought which shall embrace all natural sciences.

In regard to the condition and habitability of other spheres, one consideration—for it is absurd in the present state of our knowledge to talk of conclusions—seems to press itself upon us, namely, whether smaller orbs, as the nearer planets (Mercury, Venus, the Earth, Mars), and the satellites in the Solar system, do not mean advanced life, or (as on our Moon) life already passed away; and the larger planets, and the Sun itself, retarded inorganic and organic existence.

Those who desire to be fully informed as to Mr. Proctor's views on these matters must turn to his interesting pages; but it may be remarked here, that he believes the exterior planets to be what may be called semi-solar in their character, not only receiving heat from

the Sun, but, from their peculiar condition, having the power to impart more than they receive, and so serving as suns to their systems of satellites which he regards as true worlds. Why under these circumstances he talks of Uranus and Neptune, which he includes in his subsidiary Solar system,—indeed he speaks of Jupiter, Saturn, Uranus, and Neptune as "four suns"*—as Arctic planets it is difficult to understand.

Having dealt with what may be termed the legitimate portion of his subject—the habitability of the spheres—in the first half of his book, the author proceeds to consider such objects and phenomena as meteors and comets, the other suns, nebulæ, and he concludes his volume with a chapter on "Supervision and Controul."

We have space only for two or three passing criticisms. Mr. Proctor adopts and enlarges upon the meteoric theory of the universe, which differs from the nebular theory of Laplace, in assuming that at some time or other there was a chaos of moving meteors and that these agglomerated into masses. In our Solar system, for example, the sun first drained space of an immense quantity of meteoric matter, leaving but little in its own immediate neighbourhood, so that first smaller planets were formed; but as the attractive force of the central orb diminished, larger centres (Jupiter, Saturn, &c.) were again set up; whilst in other portions of the universe similar processes were going on. This hypothesis has received, and will continue to receive, much attention. It is a kind of Darwinian theory of the universe, not attempting to go back to the beginning (for it is as difficult to account for the formation of a *meteor* as of a *sun*), but endeavouring to reason by strict logical induction from known and present phenomena to the probable past. Whoever reads Mr. Proctor's argument, however, will be struck by his straining to appropriate all known phenomena, even such as offer contradictory evidence, in his own favour; whereas, many of his facts or supposed facts are quite as applicable to the views of Laplace as to the Meteoric hypothesis; and such phenomena as the gaseous nebulæ, their proximity to star systems, and their probable absorption by such systems, tell at least as strongly against, as for, the theory which he has adopted. Here, too, in his great flights of fancy the author fails to see the full significance of some of the phenomena to which he refers. Astronomers are in the habit of saying that we see creative processes *now* going on in the heavens; meaning thereby that we see nebulous matter being formed into worlds *to-day*. In all probability this is only true in one sense. The author, quoting an anonymous writer, shows that we see many of the distant stars, not as they are to-day, but as they were in ages past, for their distance from us is so enormous, that the light which brings us

* P. 174.

intelligence of their condition has been ages in speeding through space. The application of this fact to the appearance of nebulæ and what may be considered as worlds in course of formation, is not dwelt upon sufficiently; for just as we see the formed suns as they existed in past æons, so do we *now* observe the condition of nebulous masses as they *formerly* existed. Here, again, a little palæontology and archæology would have done the author no harm. Just as the Almighty has left us fossils in our terrestrial strata, flints in our burial mounds, and inscriptions upon our tombs to instruct us in the past history of the earth and its inhabitants, so He unfolds to us—not as with His all-seeing and omniscient faculties, but through the very imperfection of our senses, through our inability to leave the surface of our little earth, and the consequent necessity that we should stay here and await the intelligence of the past,—so, we say, he shows us the whole history of the universe at one glance, revealing to us to-day stages of formation and progress which existed at periods long past, in a ratio of time measurable by the space through which the message-bearing ray has had to pass in its mission of knowledge. In other words, as soon as our instruments enable us to measure the distance from us of a fixed star or nebula, and show us its condition, we are able to compute at what period of the past, reckoning backwards from to-day, the object we are viewing was actually in that condition, and we have therefore a more precise method of ascertaining the time which has been requisite to bring about cosmical changes than we at present possess for determining the periods required for the deposition of terrestrial strata.

As to Mr. Proctor's views on "Supervision and Controul," they are as suggestive as all his other chapters, but they are not likely to gain much favour, from the author's timidity in expressing his views on controverted subjects. It is not difficult to guess what these are; but when a writer says he will give us an insight into the nature and operations of the Almighty, but he sees no advantage in making people uncomfortable by saying what he himself thinks on just those matters on which he is best able to form a judgment, his views of Divine action are not likely to be much heeded either by "believers" or "unbelievers." The book has other faults. It is of too mixed a character, treating in some places (as where the principles of the spectroscope are explained) of physical phenomena in terms suited for a schoolboy, and in others discussing controverted points in astronomy with the earnestness and particularity of an experienced disputant, and not always without the suspicion of some little unphilosophical animus.

No one will accuse us, after these criticisms, of having followed the too common but ignoble practice of handling tenderly, if not of flattering, the productions of a collaborateur, but we are bound to

say in conclusion, that we have been much charmed by the perusal of the work. It is in many places very poetical; its author shows himself to be a careful and earnest observer, and the novel aspects in which old phenomena are presented to the reader are deeply interesting and often startling. The beautiful chromo-lithographs are amongst the best we have seen, and they convey vivid impressions of the heavenly bodies which they are intended to represent.

COMPARATIVE LONGEVITY.*

Mr. Lankester has published an Oxford prize essay on Longevity, and his little book merits the attention of a wider circle of readers than it would be likely to find within the precincts of the University. The title was, of course, not of the author's choosing, and as originally given out was as follows:—'The Comparative Longevity of different Species of Lower Animals, and the Longevity of Man in different States of Civilization.' As the author very properly says in his preface, "The subject does not admit of very satisfactory treatment from a scientific point of view, and is accordingly one which probably few persons would have selected to write upon, unless under special circumstances," "but at the same time," he remarks, "longevity is a subject of great popularity, and hence the facts and arguments herein set forth may, it is hoped, interest the public."

Although we should not feel justified in complimenting the author upon his treatment of the question from any other than a scientific point of view, and are unable to accredit him with success in having imparted greater popularity to this subject, we have no doubt that the essay will materially add to his rapidly increasing reputation as an accurate observer and promising naturalist, for every page bears evidence of careful thought and extensive reading.

In conformity with the apparent wishes of the examiners or judges, he has divided his subject into two sections, the first of which treats of longevity in organisms generally, and the second of longevity in man.

His definition of longevity would be apt to puzzle non-scientific readers, for it is "the length of time during which life is exhibited in an individual;" but the meaning intended to be expressed, as subsequently explained, is that it is the "potential duration of life" in an "individual," as distinguished from a group or succession of individuals, as in the case of asexually-produced polyps, for ex-

* 'On Comparative Longevity in Man and the Lower Animals.' By E. Ray Lankester, B.A., Oxon. Macmillan & Co.

ample. A reference to the author's carefully and conscientiously prepared "Statements as to the duration of the individual in organisms" (pp. 55 *et seq.*), shows upon what slender data he has been compelled to base his conclusions; for concerning whole groups, hardly anything appears to be known in this respect, and even where our knowledge is less scanty, line after line is preceded by the author's notes of interrogation.

His conclusions regarding the duration of life in the lower animals are as follows:—

"Hence, in spite of the great complication of the case, we may conclude, on both deductive and inductive grounds, that the high or low potential longevity of different species, as a general law, is necessitated by those conditions of life which necessitate high or low individual development, as the case may be, whether of bulk, or complexity, or both, that it is directly subject to those conditions which cause personal expenditure to fluctuate, or which affect generative expenditure, being high when these are low, and low when these are high; that these relations, interacting and contending variously according to the special case, determine the potential longevity of the various species of lower animals.

"From the intricacy of these relations we may conclude that potential longevity is a very delicately balanced quantity, and that very *slight* causes may produce great fluctuations in it and be almost impossible to trace; the magnitude of the result being far larger in proportion to the magnitude of the initial cause, as is so often found to happen in biological science" (pp. 87–88). It may be as well to add, by way of explanation, that the author means by personal expenditure, "that involved in the wear and tear of assimilating food, and generally carrying on life" (p. 48).

When he comes to treat of longevity in man, his essay, as might be expected, is more popularly interesting, and its interest is enhanced by the originality of some of his observations. He attributes a longer life to man in civilization than in a state of nature. "Civilized man," he says, "lives in societies, one of the most essential bonds of union in which is the maintenance to a greater or less extent by the community of the feeble. The security which the healthy and vigorous man hopes for himself when grown old and feeble he naturally extends to others, and thus the aged are fed and protected as the result of a specific habit or characteristic among men (the most barbarous excepted)" (p. 88). This is the scientific re-statement of the commandment, "Honour thy father and thy mother, that thy days may be long upon the land which the Lord thy God giveth thee."

The author's account of the rise and spread of our race, and his partial application of Mr. Darwin's theory, only disappoint us by their brevity, and his conclusion is incontrovertible that "individual

men do not struggle for existence—that is assured to them by society—they struggle "to get on." This is practical Darwinism, and the author shows that the expenditure of brain-power in man's case affects the potential duration of his life. He reviews carefully the phenomena bearing on this aspect of the question on savage and civilized life, and his conclusion is, "that a civilization of the highest order in which the efficiency of the community and the efficiency of the component individuals is greatest—in which there is the most harmonious action, the greatest happiness for the greatest number, the least excessive expenditure with the least luxury, where regularity and temperateness are innate characteristics, will be that state of civilization most favourable to longevity."

But there is a set-off against this: great thinkers do not live so long as those who take things more easily, and we find from his tables that *less* distinguished men in every profession enjoy longer lives (in one sense of the word "enjoy") than those who are more distinguished. If the millennium were reached, "men would no longer die of disappointment, but would all attain 80 or 100 years. There is no apparent reason why longevity should not increase beyond that limit, and advance with advanced evolution, and the diminished expenditure implied in complete adjustment" (p. 128). There is, however, another matter to be considered: Will not the limited area of our globe be pretty well covered with human denizens before that happy day dawns upon us? and what then? However, that is a matter for posterity to consider; and meanwhile we cordially recommend Mr. Lankester's suggestive little volume to our biological readers.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

The extreme drought of the past three months is by far the most important of recent agricultural events to put upon our record. Already, in early June, throughout the southern counties, pastures are becoming bare and brown, and spring-sown crops are dwindling. Clover and other forage crops are not yielding half their usual produce to the scythe; wheat alone has not yet materially suffered, but a continuance of dry weather must injure the wheat harvest too. Wheat, indeed, "needs no rain after May;" but that is only when May itself has soaked the ground. The usefulness of artificial manures depends very much on the wetness of the growing season. No applications in the way of top-dressings to growing crops are made when they would obviously be useless; and this great aid and stimulant to fertility being lost, the year's produce thus suffers indirectly also from the drought. The Cirencester Chamber of Agriculture has reported the favourable results of top-dressings of nitrate of soda and superphosphate of lime on the wheat and barley crops of the Cotswold soils. On three experimental plots, the average increase of grain per acre per 100 lbs. of the former dressing by itself was 276 lbs. The average increase per acre of four plots per 100 lbs. of the former together with 200 lbs. of the latter dressing was 517 lbs. of grain. In other cases the difference due to the added superphosphate was not so great; but the conclusion, upon the whole, seems to have been that nitrate of soda, applied as a spring top-dressing to wheat, whether by itself or not, yields a satisfactory increase of produce; though the result of the combined dressing of superphosphate together with the nitrate was still more satisfactory. The practice of top-dressing grain crops in spring is a growing one; and as no one thinks of making this application, except in wet weather, this is an advantage which this year's harvest will have lost.

Dr. Voelcker continues to report to the Royal Agricultural Society of England the results of his constant analyses of commercial manures and cattle foods—showing to how much fraud and roguery English agriculturists are exposed. Guano is this year unusually various in its composition—even genuine Peruvian guano is sometimes damaged by sea-water, or contains an excessive quantity of sand. Samples are reported containing as much as 17 per cent. of water and 5 to 9 per cent. of useless mineral matter, and only 12 to 13 per cent. of ammonia—being thus worth less by 30s. or 40s. a ton than the price at which Peruvian guano is now sold.

Another artificial guano, containing 26 per cent. of water and 60 per cent. of lime and sand, &c., and not 1 per cent. of ammonia, is sold at 70*s*., while it is not worth carrying a mile if it could be had for nothing. Other manures still occasionally find purchasers, though absolutely worthless, or even mischievous. Oil-cakes of various kinds, as well as fertilizers, pass through Dr. Voelcker's hands, and faulty samples, under analysis, lose the character under which they have been bought and sold: and the publication by the Royal Agricultural Society of these investigations by their chemist must ultimately prove serviceable.

A very instructive discussion by Mr. Lawes on the waste of food during respiration has been published with a view to the elucidation of sound farm practice in the meat manufacture. It is obvious, as he points out, that in the case of animals fed for the butcher the economy of the feeding process will be the greater, the less the amount of food expended by respiration in the production of a given amount of increase; and it is equally obvious that one ready and efficient means of lessening the proportion of the waste or expenditure to the increase produced, is to lessen as far as possible the time taken to produce it; in other words, to fatten as quickly as possible. From numerous experiments made at Rothamsted it appears that a pig weighing 100 lbs. will, if supplied with as much barley-meal as he will eat, consume 500 lbs. of it, and double his weight—that is, increase from 100 lbs. to 200 lbs. live weight—in seventeen weeks. Of the 420 lbs. of dry substance which the 500 lbs. of barley-meal contain, about seventy-four are stored up in the 100 lbs. of increase in live weight, about seventy are recovered in the manure, and 276, or nearly two-thirds of the whole, are given off into the atmosphere by respiration and perspiration—that is to say, are expended in the mere sustenance of the living meat-making machine, during the seventeen weeks required to produce the 100 lbs. of increase.

Mr. Lawes points out that if instead of allowing the pig to have as much barley-meal as he will eat, the 500 lbs. of meal had been made to last many more weeks, the result would have been that the animal would have appropriated a correspondingly larger proportion of the food for the purposes of respiration and perspiration, and a correspondingly less proportion in the production of increase. In other words, if the 500 lbs. of barley-meal were distributed over a longer period of time, it would give less increase in live weight, and a larger proportion of it would be employed in the mere maintenance of the life of the animal. Indeed, if the period of consumption of the 500 lbs. of meal be sufficiently extended, the result will be that no increase whatever will be produced, and that the whole of the food, excepting the portion obtained as manure, will be expended in the mere maintenance of the life of the animal.

The conclusion is obvious, that, provided the fattening animal can assimilate the food, a given amount of increase will be obtained with a smaller expenditure of constituents by respiration, the shorter the time taken to produce it. In fact, by early maturity, and the rapid fattening of stock, a vast saving of food is effected.

Mr. Lawes has lately made a practical use of the conclusions to which his Rothamsted researches have led him in connection with another branch of farm practice. In a paper read before the London Farmers' Club on the exhaustion of the soil in relation to landlords' covenants and the valuation of unexhausted improvements in favour of an outgoing tenant, he drew a distinction between the natural fertility of a soil, which is the property of the landowner, and the "condition" of the soil, which is often properly the property of a tenant. The following are the practical results which he considers follow upon his discussion of this subject:—

"Condition" is a quality distinct from natural fertility of soil, and is mainly dependent on the amount of capital expended by the tenant in the purchase of cattle food or manures. It is, therefore, his property, and may be easily and rapidly reduced. —The natural fertility of a soil, on the other hand, whether high or low in degree, is, comparatively speaking, a permanent quality; it can only be injuriously affected by the continuance of an exhaustive system of cropping for a long period of time; it is the property of the landlord; and, excepting in the case of very light soils, it is the chief element in determining the rent-value of the land.—No injury is likely to result to the landlord in the case of the heavier soils from granting the tenant permission to crop as he pleases, provided he be bound to keep the land free from weeds, and to leave a fixed proportion under fallow and green crops at the termination of his occupation.—By the valuation of so much of the farmyard manure, and of so much of the manure constituents derived from purchased cattle food, as have not yet yielded a crop, and also of the straw of the last harvest, fair compensation may be made to the outgoing tenant.—If abundant capital is to be attracted to the soil, it is essential that liberal covenants in regard to cropping should be adopted, and fair compensation for unexhausted improvements made.

Among the remaining principal events which have lately happened in the agricultural world must be named the remarkable favour with which the so-called A B C process for dealing with the town sewage nuisance has been received by many towns on which the adoption of it has been urged. Chemical analysis does not endorse the extravagant assertions which have been made regarding the merits of the process. The water is still foul after sewage has been acted on by the A B C mixture; and the dried mud which it throws down, for which 70s. a ton is the price demanded, is not worth, even

theoretically, one half that sum; while, practically, it must be pronounced of very little value indeed. The valuation of 1 or 2 per cent. of "combined nitrogen" in the midst of a mass of clay and other inert mineral matters cannot be conducted on the same scale as is applicable to the ammonia of a manure in which it forms $\frac{1}{6}$ or $\frac{1}{7}$ of the total weight. And in addition to the lower theoretical value of "combined nitrogen" in this diluted form, it is practically so much the less valuable on account of being loaded with a lot of worthless stuff, the expense of applying which to the land has to be deducted from any result of the application which may be due to the small quantity of fertilizing matters with which it may be charged. Nothing connected with this or any other scheme for sewage utilization has at all shaken the conclusion, to which the Rivers Pollution Commissioners had been led by their investigations, that sewage irrigation is not only the best method of sewage defæcation, but the only known plan by which its filth may be profitably converted into fertility.

2. ARCHÆOLOGY (Pre-Historic).

'Flint Chips' is the title of a book just issued by the Trustees of the Blackmore Museum, Salisbury, written and compiled by Mr. Edward T. Stevens,* their honorary curator. Few private gentlemen have merited the thanks of men of science more justly than Mr. William Blackmore, by whose munificence the town of Salisbury has been enriched with the excellent Museum of Prehistoric Archæology described in the clearly-written and well-printed pages of the book before us.

Mr. Stevens's work has been written with a view to illustrate the Stone age by the help of the collections in the Blackmore Museum; but he has really done far more than this, for we learn from these pages the history of "Wampum"—that very useful article in whatever part of the world we may be cast—of the earliest known evidence of the use of tobacco as evidenced by the "Mound City" explorations; of the cultivation of maize and other cereals; of the early evidence of the manufacture and the use of pottery; of weaving, spinning, &c., as practised by aborigines; of ornaments in gold, silver, and bronze; of weapons of war and the chase, and how they were used; of the animals found with primitive man; of the houses he dwelt in above-ground, above-water, and underground; and, lastly, of his burying-places and religious rites for the dead.

These and a hundred other topics Mr. Stevens has brought

* 'Flint Chips: a Guide to Pre-historic Archæology.' By E. T. Stevens. London. 8vo, pp. 632. Bell and Daldy. 1870.

together in a useful form in his book, all that he says having a reference to the collections in the Blackmore Museum, yet giving sufficiently clear information upon each subject to interest the general reader who may never be able to visit this most interesting place.

The arrangement of the Blackmore Museum consists mainly of four great groups:—1. The remains of animals found associated with the works of man. 2. Implements of stone. 3. Implements of bronze. 4. Implements, weapons, and ornaments of modern savages, which serve to throw light upon the use of similar objects belonging to pre-historic times.

The mammalian remains are described by Dr. H. P. Blackmore. These consist chiefly of a local series from Fisherton, near Salisbury, associated with stone implements of the palæolithic type. "The animals," says Dr. Blackmore, "which lived in our country whilst the drift-beds were being deposited, differed strangely from those with which we are now familiar, and afford the most conclusive evidence of the greatly altered condition of our climate. The musk-sheep, reindeer, lemmings, pouched marmot, mammoth, and woolly rhinoceros are all animals peculiarly adapted for living in an Arctic clime. Our downs were tenanted by vast droves of rather small but hardy horses, not unlike the half-wild forest ponies of the present day, by large herds of deer, and shaggy-maned bisons. The stillness of the night, we may imagine, was not unfrequently broken by the terror-inspiring roar of a hungry lion, or perchance by the howling of a pack of wolves, or the hideous discord of the savage hyænas quarrelling over some half-putrid carcase—making the air re-echo with their peculiar yells."

There is good reason to believe that the Blackmore Museum, although not so extensive in every department as some of the Continental museums, is nevertheless one of the best in Europe.

But what adds perhaps the greatest value to the Collection, and what, for purposes of comparison, places it above all others, is the suite of American antiquities obtained by Messrs. Squier and Davis in their explorations of the tumuli and mounds of the valleys of the Mississippi and Ohio. This was the finest collection of its kind in the United States, and it is doubtful whether one of equal extent, and so rich in the works of primitive man, can again be made in America; indeed many of the specimens are unique. Apart from the general merit of the Blackmore Museum as illustrating pre-historic archæology in a singularly successful manner, the fact of its containing this remarkable American collection gives it at once a distinctive character, and offers a special object to reward the archæologist who may visit this ancient city—already famous for its magnificent megalithic remains at Stonehenge on Salisbury Plain, once the home of the bustard, the last of our large indigenous wild birds exterminated by man.

*Part X. of 'Reliquiæ Aquitanicæ'** has come to hand since our last Chronicle was written. M. Lartet commences in this number a very admirable article on the employment of sewing-needles in ancient times, illustrated by a plate and numerous wood-cuts of bone and bronze needles.

The bone needles from the caves have nearly all rounded stems, and in most cases they have been carefully polished. Narrow pieces of the hard exterior of the bone or horn were carefully isolated by parallel cuts with a flint flake, and when quite detached the splinter was rubbed into proper shape on a sandstone rubber, and polished on a skin. The eye of the needle was drilled with a pointed flint drill. Some needles figured exceed three inches in length, and, in finish, are as slender as a German-wool-work needle or large darning-needle of the present day. It is very interesting to find in the same cave with the finished needles, the half-made needles (partially cut from the horns of reindeer, the bones of a bird, the metatarsal of the reindeer, and the metacarpal of the horse) and the "wasters," also the instruments used for their manufacture, showing that the cave-folk of the reindeer period were as well accustomed to make and use the needle in the preparation of articles of dress as are the modern Esquimaux. It is also (as M. Lartet observes) but reasonable to suppose that, like the Esquimaux, they used the sinews of the reindeer for their thread, as there is equal justness in inferring that their dress was composed of the skin of these animals so abundant throughout the region of Aquitania in pre-historic times. M. Lartet thinks the long needles may have been used for embroidery, as they would have been too delicate to use for ordinary sewing or stitching of skins, for which the short stout needles seem best adapted.

An interesting account is given of the preparation of the skins by the Esquimaux, and their methods of sewing and ornamenting their dresses.

The cave-folk of the Reindeer period were quite unacquainted with the sheep, and although, like some modern aborigines, they had a prejudice against the hare and rabbit, yet they seem to have killed them for the sake of their fur, to use, it is supposed, as the Laplanders do, to trim the borders of their dresses with.

Before concluding this account, it is interesting to note that the eyed needles were not found indifferently in all the stations of that period. At Les Eyzies, Laugerie Basse, and at La Madelaine in Dordogne, the largest quantity of needles have been collected and always associated with harpoon-heads of the barbed type. It is also

* 'Reliquiæ Aquitanicæ: being contributions to the Archæology and Palæontology of Périgord and the adjoining provinces of Southern, France.' By Edouard Lartet and Henry Christy. Edited by T. Rupert Jones, F.G.S. London. H. Baillière.

with these barbed weapon-heads that similar needles have been found in the Bruniquel Cave by the Vicomte de Lastic, and in the rock-shelters of the same place, so successfully explored by M. Brun, of Montauban. They have been found in similar association in the lower cave of Massat (Ariège).

From the cave of Veyrier at the foot of Mount Salève, which belongs, like those of Les Eyzies, La Madelaine, &c., to the artistic portion of the Reindeer period, and where the antlers of this ruminant have been found having figures of animals and plants engraved upon them; needles have also been obtained, one of which appears to be made of ivory.

In the older caves, like that of Aurignac (Haute Garonne), Les Fees (Allier), and the Gorge d'Enfer, where remains of the reindeer are less abundant, and at the same time the Quaternary fauna is more completely represented by extinct species, eyed needles have not as yet been met with. Simple awls, made of bone or ivory, seem to have served in their stead, whilst the modern *barbed* type of weapon-head is not found, but in its place the older lanceolate form.

Eyed needles have been discovered in the Swiss-Lake habitations and elsewhere; but in general these needles, though belonging to times comparatively more recent, are far from being as well shaped as those of the artistic epoch of the Reindeer age.

Discovery of a Pre-historic Dwelling on the Coast of Haddingtonshire.—A short note by Mr. J. W. Laidlay, F.S.A., F.G.S., on a pre-historic dwelling and kitchen-midden, discovered by him on a small rocky peninsula near Seacliff on the coast of Haddingtonshire,* is of great interest as deciding against the theory, put forward so ably by Mr. Archibald Geikie, and subsequently by Mr. T. Smyth, that the shores of the Firth of Forth had risen at least 25 feet since the time of the Roman occupation.†

The rock in question, situated about three miles east of North Berwick, on the south side of the Firth of Forth, is isolated at spring tides, but is at other times separated by the sea from the mainland. The remains found upon the rock were, first, the foundations of an ancient building, consisting of stones selected apparently from the beach, and joined together only with earth or mud; being two or three courses in height, but concealed until recently by a thick coating of turf; secondly, a large quantity of rude hand-made pottery in fragments, a number of implements of bone, such as needles, arrow-heads, combs, knives, chisels, &c., very similar in point of manufacture to those from the Swiss-Lake dwellings of the Stone period; thirdly, a vast quantity of bones of oxen (exhibiting

* See the 'Geological Magazine,' vol. vii., June, 1870., p. 270.
† See ibid., vol. ii., 1865, p. 181.

considerable variety in proportions, and including *Bos longifrons*) sheep, goats, deer, swine, dogs, &c.; of shells, in great abundance, especially those of *Patella vulgaris* and *Littorina litorea;* a very rude querne, &c. All of these have been deposited in the Museum of the Society of Antiquaries of Scotland, in Edinburgh; and are considered, by those best qualified to judge of their age, to belong to a period certainly as remote as the Roman occupation, or even earlier. This opinion is greatly confirmed by the absence of all trace of metallic implements, notwithstanding the most diligent efforts on the part of Mr. Laidlay and his sons to discover any such by having the entire soil upon the top of the rock (of which there were many cart-loads) all carefully sifted by hand.

This rock is not more, as to its lower part, than 22 or 23 feet above high-water mark. Assuming that its age extends beyond the historic period, it seems clear that, if the assumed elevation of this coast, already mentioned, had taken place since the time of the Romans, this rocky promontory would not merely have been uninhabitable at high water, but it would have been actually submerged. As it is at present, the sea in rough weather renders it hardly endurable to remain on the rock; whilst a very slight depression would enable the waves to make a clean breach over it.

Dépôt for the Manufacture of Flint Implements.—The investigation of the so-called "Devil's Pits" and "Grimes' Graves," near Brandon, Norfolk, show that the working of flint at this spot dates back to a far earlier period than the manufacture of gun-flints, now also almost a thing of the past. The bottom of the pit has been reached, disclosing a network of galleries extending into the chalk in various directions. At the end of No. 1 Gallery a fine ground-stone hatchet was discovered, and two well-worn horn-picks. These caves were doubtless pre-historic chalk-workings for obtaining flint for the manufacture of implements of which such numbers have been obtained from the river-valley gravel close by.

The early flint-implement makers of the Stone age seem to have been as fully aware of the advantage of working a freshly dug out flint as the modern gun-flint makers, a race of artisans now nearly extinct.

Ancient Kitchen-middens in the Andaman Islands.—Dr. Stolickza has lately communicated to the Asiatic Society of Bengal an account of a visit made by him to the Andaman Islands.

These islands, inhabited by probably one of the very lowest types of aborigines known, have abundant "refuse-heaps" of evident antiquity, composed of shells, bones of the Andaman pig, stones, and broken pottery. One of these mounds, which Dr. Stolickza examined at the north end of Chatham Island, was 12 feet in height, and about 60 feet in diameter; it had been long undisturbed, as

large trees were growing upon it. Besides pottery of the rudest description and stone hammers, a few polished celts and a typical arrow-head have been picked up. The mounds, so far as they have been examined, afford no evidence of human bones to support the charge of cannibalism brought against the Andamanese, whose ancestors no doubt left these middens, seeing that similar heaps are now being formed by the natives at all their favourite places of resort around the coast.

Cannibalism in Namur.—M. Spring, the Belgian anthropologist, after an examination of the cavern of Mont Chauvaux (Namur), has satisfied himself that the men, whose bones are there found mixed with those of deer and oxen, were cannibals. He further concludes that they were so from choice, not from necessity; for the roasted bones are not only those of the aged, but also of young women, boys, and infants.

Mr. Darwin mentions that the Tierra del Fuegians in times of scarcity eat the old women first and their dogs last, the former being an incumbrance, whilst the latter assist in procuring food.

Ethnological Society.

Colonel Lane Fox (March 8) read a paper "On the Opening of two Cairns near Bangor, in North Wales." One was situated on the summit of Moel Faben, and contained a cist, in which was placed an urn, together with several small dressed stones, probably arrow-heads, and flakes, worked, not in flint, but in the trap and felspathic rocks of the neighbourhood. Other worked stones were found beneath the cist. Professor Ramsay described the nature of the materials used. The second cairn examined, called Carnedd Howel, contained fragments of an urn surrounded by fragments of burnt human bones, but not protected by a cist.

The Rev. J. C. Atkinson (April 12) made a communication "On the Danish Element in the Population of Cleveland in Yorkshire." The author showed that not only many words in the Cleveland dialect, and a very large proportion of personal and local names in the district, are of Scandinavian origin, but also that many of the idioms are markedly Scandinavian. He also traced an old Anglian element in the dialect of the people.

Dr. Donovan (April 26) read a paper "On the importance to the Ethnologist of a careful study of the characters of the Brain in different Races." This was followed by one from Mr. E. B. Tylor, "On the Philosophy of Religion among the Lower Races of Mankind." The author ascribed the first ideas of religion to a belief in spiritual beings (*Animism*). The idea of a soul extended to animals, plants, and even inanimate objects. To such spiritual beings are

ascribed the phenomena of disease, especially epilepsy and mania. Trees, rivers, sun, moon, heaven, earth, &c., furnish other spiritual beings, which again are divided into favourable and harmful spirits, causes of good and evil, and thus Dualism is a fundamental principle in the religions of the lower races. The culminating notion of a Supreme Deity is well known to many of these races.

The President, Professor Huxley (May 10), delivered an address on the Ethnology of Great Britain.

He showed that the oldest accounts of the peoples of these islands prove the existence of two types of people, physically distinct—the one tall, fair, yellow-haired, and blue-eyed; the other short and dark, with dark hair and black eyes. This dark type, as exemplified in the ancient Silures, closely resembled the people of Aquitania and Iberia, whilst the fair type bore considerable resemblance to the Belgæ of north-eastern France, and what is now called Belgium. Both peoples spoke dialects of a Celtic language. Professor Huxley did not consider that the invasions of Britain really introduced a new element into the pre-existing population; it seems doubtful if the Roman occupation strengthened the fair or the dark element. The invasions of the low Dutch and the Danes strengthened the fair element.

In the paper which followed, the Rev. Dr. Nicholas endeavoured to show that "the influence of the Norman conquest on the Ethnology of Britain" was greatly gainful to the old British or Gallo-Celtic population, seeing that the Normans, so-called, were in a far greater degree Cymric and Gallo-Frankish in blood.

In his Anniversary Address (May 24) Professor Huxley spoke of the efforts that had been made to amalgamate the Ethnological and Anthropological Societies, and pointed out the desirableness of union between the several Societies having kindred objects in view.

Anthropological Society.

Two papers were read before this Society on April 5th, by Mr. Hodder M. Westropp, and Mr. C. Staniland Wake, the former entitled "On Phallic Worship," and the latter "On the Influence of the Phallic Idea in the Religions of Antiquity."

On the 19th April, Mr. Alfred Sanders read a paper "On Mr. Darwin's Hypothesis of Pangenesis as applied to the Faculty of Memory."

Mr. George C. Thompson contributed a note "On Consanguineous Marriages." From the paper and its discussion it would appear that the practice of interbreeding was not only not necessarily injurious, but *by judicious selection* an improved race of men might be obtained. The difficulty of course, is to carry out in

practice what Dr. Langdon Down is theoretically satisfied would be of enormous value to the community, men not being like race-horses or oxen.

Major W. Ross King, on May 3rd, communicated an account of the "Aboriginal Tribes of the Nilgiri Hills," known as the Todas, Khotas, Erulas, and Kurumbas, especially noticing the former as the most singular and important. The author described the characteristic features and peculiarities of each; their social customs and religious rites, showing that even in a limited area, like the Nilgiris, several tribes may exist, each preserving its own language and customs; and all remaining perfectly isolated from the enormous populations of the plains. The presence of Druidical circles, cromlechs, kistvaens, and tumuli, on the Nilgiri Hills, offers a striking resemblance to those of our own country, and suggests the possibility of an early western migration of pre-historic peoples from this cradle of the East.

On the 19th May a large gathering of anthropologists and their friends took place at St. James's Hall, to hear Mr. Henry F. Chorley's paper "On Race in Music." Mr. Dannreuther illustrated the paper by numerous examples on the pianoforte.

On the 31st May, Dr. John Shortt read a paper "On the Armenians of Southern India;" and Mr. John Stirling "On the Races of Morocco."

The Ancient Cemetery at Frilford.*

Almost the only source of information we possess capable of being used either to check off, or to throw light upon, the early history of our Romano-British and Anglo-Saxon ancestors—a well-nigh pre-historic epoch in this country—is derived from a study of the early graves and barrows scattered over this island far and wide, many of which have yielded evidence of the highest import to the historian, archæologist, and ethnologist.

In the paper before us, Professor Rolleston has given a most complete and exhaustive memoir upon the remains obtained by him during a two years' exploration of the ancient burying-place at Frilford, near Abingdon, Berkshire.

The cemetery is situated in the angle between the left bank of the river Ock and the road leading from Frilford to Wantage. Frilford "Field" is now brought under cultivation, but the tra-

* Although this subject barely comes within the scope of this Chronicle, it is inserted here on account of its connection with Anthropology.

'Researches and Excavations carried on in an Ancient Cemetery at Frilford, near Abingdon (Berkshire), in the years 1867 and 1868.' Communicated to the Society of Antiquaries by George Rolleston, M.D., F.R.S., Linacre Professor of Anatomy and Physiology in the University of Oxford. 1870. 4to. [Reprinted from the 'Archæologia,' vol. xlii., pp. 417–485.]

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dition that this portion of it is haunted still survives in the recollections of the rustics, one of whom told Dr. Rolleston that, although he had never seen one himself, ghosts were supposed to be particularly likely to be seen at a single thorn-bush which stood some time back close to the site of these graves.

Dr. Rolleston is not the first who has devoted his attention to this fruitful spot. Mr. Akerman had, in 1865, furnished an account of excavations in this same locality to the Society of Antiquaries.

But the present is by far the most complete and exhaustive memoir yet published, giving, as it does, a careful account of the exhumation in a more or less complete state of 123 separate individuals, probably the largest number ever yet examined by any one savant from a single locality. The exploration of the ground has resulted in the discovery of Roman remains in lead coffins, Romano-British remains in ordinary graves, and Anglo-Saxon skeletons having ornaments associated with them belonging to that period, also undoubted Anglo-Saxon cinerary urns containing half-calcined human bones. Dr. Rolleston has discovered that these numerous interments, representing several separate periods of time, are also placed at different levels in the soil, the Anglo-Saxon cinerary urns having been so slightly interred as to have, in one instance, been actually cut by the ploughshare.

In spite of the ravages of fire, in the cases of cremation, and the all but equally destructive working of the water, containing carbonic and other acids, upon inhumation in ground with the rock (Coralline Oolite) within an average distance of about a yard from the surface, it has been found possible to identify the sex and age in all but about a sixth of the skeletons, or parts of the skeletons examined. Many skeletons, however, and many urns have been lost to science during the various quarrying operations carried on previously to Mr. Akerman's report in 1865.

Great numbers of Roman coins have been and still are found by agricultural labourers, when at work, all round this spot; and also fragments of very many varieties of Roman pottery. There is much other evidence to show that Roman civilization had taken firm root in this locality; for not only have three or four Roman leaden coffins been found containing human skeletons and coins (of Constantine jr., Valens, and Gratian, A.D. 383), but about a couple of hundred yards distant from the cemetery, having observed the greater greenness and strength of the crops upon two patches of ground, Mr. William Aldworth, the liberal owner of the soil, permitted the ground to be opened with the result of finding for a depth of ten feet or more, an aggregation of fragments of pottery of the most varied patterns and degrees of fineness mixed up with similarly fragmentary bones of the ox, sheep, pig, and dog, and with other articles, such as a key, a spoon, knives, a bronze ring, a

hair-pin, coins, &c., which, like the bones and shards specified, would be expected in the rubbish-heap of a great house. The site of the house Mr. Rolleston did not find, but he thinks the quarry, whence the stones for its construction were taken, was converted afterwards into, and is now represented by, one or other or both of the rubbish-pits.

Professor Rolleston has given most carefully-prepared lists of all the remains found in the various graves which he divides into those :—

In leaden coffins (Roman period), 6.
Romano-Britons, 31 men, 22 women.
Supposed Anglo-Saxons (but without relics), 3 men, 3 women.
Anglo-Saxons, with relics or in urns, 21 individuals.
Other skeletons, 15. Children found without relics, 23.

One of the most striking peculiarities of this series is the very large proportion of aged persons; but a closer inspection shows that the proportion varied most surprisingly in accordance with the nationality. Out of the undoubted Anglo-Saxon interments only two could have been considered old. This may have resulted from the mortality inevitable in the ranks of all successful invading armies, especially such undisciplined troops as composed the Saxon hosts.

The preponderance of aged Romano-British skeletons may be not only the result of more settled conditions, but may also be explained, Professor Rolleston thinks, by the hypothesis that the young men had been taken away to fight and die in distant countries under such commanders as Magnus Maximus.

This state of things is well understood in France and elsewhere, where conscription is practised in time of war.

In discussing the variations in the series of skulls exhumed at Frilford the author well remarks that "most or all invasions entail more or less of intermarriage between the invaders and the invaded; and the craniographer who considers what very motley hordes passed into England under the names of 'Roman' and 'Saxon' respectively, and for what long periods these immigrations continued to be made, will be cautious as to his inferences."

We might follow Professor Rolleston through the detailed account of this laborious investigation; the subject is one of deep interest, but we have said sufficient to show the import and nature of the author's researches, and to commend him as a sure and experienced guide, both in archæological and ethnological inquiries. To those who have not seen the Oxford Museum, the fact of its being the depository for this wonderful series of remains may serve as a further inducement to pay it a visit.

3. ASTRONOMY.

(*Including the Proceedings of the Astronomical Society.*)

The attention of astronomers is becoming more and more directed towards the preparations which are being made for observing the total eclipse of December 24th next. There seems every reason to believe that the English corps of observers will be far more effective than any which this country has hitherto sent to observe a total eclipse. Spectroscopy, photography, and polariscopy, will be entrusted to the charge of those who are best fitted to superintend the details by which these modes of research can alone be rendered successful. As yet the arrangements have not been fully decided upon, though they will probably be known before these pages are printed. At present it is understood that there will be two expeditions, one to Spain, the other to Sicily. Each will consist of about thirty persons; and each will include, besides one or two general observers, three distinct parties, the spectroscopic observers, the observers with the polariscope, and the photographers. It has been proposed that the three parties forming the Spanish expedition, should be headed respectively by Mr. Huggins, the Rev. C. Pritchard, and Mr. Browning. As regards the parties forming the Syracusan expedition, it has been proposed that Mr. Lockyer should head the spectroscopists, and Mr. Brothers the photographers, the polariscopic department not having as yet been assigned to any specified chief.

Everything promises well for the success of these expeditions, since we learn from Lieutenant Brown, whose long residence at Gibraltar renders his opinion especially valuable, that the weather is, on the whole, more likely to be clear and settled in December than in any other month of the year. The Poet Laureate has volunteered to join the expedition, and we may perhaps hope to have from his pen such a description of a total eclipse as will be at once worthy of the subject and of his powers.

The observers must not forget, however, that nothing but the utmost care and the most thoughtful consideration beforehand of all the difficulties they are likely to be troubled with, as well as of all the methods by which they may secure reliable results, will serve to render the expedition successful. It must be remembered that the points to be determined—the nature and structure of the corona—are questions of extreme difficulty and delicacy, which have already foiled the exertions of the able astronomers who have observed the last two total eclipses. During the present eclipse totality will not last more than half as long as during the eclipse of 1869, and scarcely one-third as long as during the eclipse of 1868. It will tax the powers even of the skilful observers about to take part in

this important work, to learn something new about the corona during the two minutes of total obscuration.

The discovery that the star Eta Argûs, around which the most amazing nebula in the whole heavens spreads itself in fantastic convolutions, is shining with the light of burning hydrogen, is, perhaps, when rightly understood, the most instructive fact which has been revealed by astronomical observation for many past years. We know that this star is now nearly at its minimum of brightness, and astronomers confidently expect that in the course of the next half century it will rise from its low estate as a sixth-magnitude star until it again outblazes even Canopus in splendour. That this star, like the new star which lately shone out in Corona, is surrounded by hydrogen-flames, seems clearly established by the observations of Mr. Le Sueur at Melbourne. He has not been able, indeed, to test the character of the bright lines across the star's faint continuous spectrum, by actually bringing them into juxtaposition with the lines of hydrogen. But he has been able to measure their position with considerable accuracy. He finds, by spectroscopic observation, that the space around the star is really free from nebulous light, and is not merely dark by contrast; and he deduces the conclusion that the star has been fed, so to speak, by the matter of the nebula, since the nebulous light which appears at some distance from the star exhibits one of the hydrogen bright lines. This view may well be demurred to, since it would render the restoration of the star's light a simple impossibility. And besides, when Sir John Herschel observed the star in 1837, the nebula was bright all round the star; whereas, since the star was then shining very brightly, the nebula should have shown signs of having been consumed near Eta Argûs, were Mr. Le Sueur's theory correct. It seems far more probable that the amazing variability of this nebula is due to the motion of its parts, and is associated with the equally amazing variability of Eta Argûs in such sort that, when a rich region of nebulous matter is brought to the star's neighbourhood the star becomes bright, while when, as now, the star is surrounded by a region bare of nebula, its light sinks low.

One fact, at any rate, seems placed beyond all question by Mr. Le Sueur's researches. We can scarcely doubt any longer that the nebula and the star are intimately associated, or that the strange variation of one is but the counterpart and measure of the variation of the other.

Mr. Browning's invention of the automatic spectroscope is full of promise for the advancement of our knowledge of the constitution of the celestial bodies. This is not the place to enter into a consideration of the advantages it presents over all other forms of the spectroscope; but our Chronicle would have been incomplete without a few words of comment on this most ingenious addition to our means of

research into the physical habitudes of the orbs which people the celestial depths.

Professor Kirkwood's ingenious hypothesis that the periodicity of the solar spots may be referred to the existence of solar regions favourable to the development of spots, has received its death-blow at the hands of Sir John Herschel. Our veteran astronomer is still ready to devote his great powers to the study of such questions. In this case he has been at the pains to mark down the exact place on the sun's *globe* of all the spots observed by Carrington. He finds no trace of a region where sun-spots occur with unusual frequency, or if there are traces of such a region they are so slight as to afford no sufficient foundation for Professor Kirkwood's hypothesis.

Professor Kirkwood's detection of the law that comets of small perihelion distance have their perihelia nearly in the direction towards which the sun is travelling, has been followed up by a careful investigation of the periods of some of the meteoric rings. The April shower, though less familiarly recognized than the November and August showers, is yet too well marked not to be admitted among the periodical meteoric systems. Professor Kirkwood shows that this system cannot be associated, as Weiss suggested, with the first comet of 1861; but by comparing the dates on which remarkable showers of meteors belonging to this system have appeared, he exhibits the probability that the system has a period of $28\frac{1}{3}$ years, and an aphelion distance very nearly equal to the mean distance of Uranus. Dealing with the meteors of December 11–13, he finds for them a period of $29\frac{1}{6}$ years. For the meteors of October 15–21, he obtains a period of $27\frac{1}{2}$ years. He adds, "if these periods are correct, it is a remarkable coincidence that the aphelion distances of the meteoric rings of April 18–20, October 15–21, November 14, and December 11–13, as well as those of the comets, I. 1866 and I. 1867, are nearly all equal to the mean distance of Uranus." As Jupiter has his family of dependent comets, so distant Uranus has depending from his orbit a family of meteoric and cometic systems. Can we suppose that those among these meteor-systems which intersect the orbit of the earth are all which thus depend on Uranus, or that they form a thousandth or even a millionth part of his family of meteor-systems? The laws of probability are enormously against such a supposition; and if it be indeed true (as we seem forced to admit) that around the orbits of the major planets there cling these myriads of meteoric and cometic systems, we obtain a new insight, indeed, into the characteristics of the solar system.

Saturn will continue to be favourably visible during the ensuing quarter. Mars, Venus, and Jupiter will be unfavourably situated. We remind our readers to look out for shooting-stars on the nights of August 9–13.

There will be a total eclipse of the moon, visible at Greenwich, on July 12. The first contact with the penumbra will take place at 7h. 46m. P.M., first contact with the shadow at 8h. 45m. Totality will commence at 9h. 44m. and end at 11h. 24m. Last contact with the shadow will take place at 12h. 24m., last contact with the penumbra at 1h. 22m. on the morning of July 13. On July 27th there will be a partial eclipse of the sun invisible at Greenwich.

Proceedings of the Astronomical Society.

Lieut. Herschel, in a paper on "Dark Objects crossing the Solar Disc," describes how he was for some time deceived into the belief that a flight of meteors was crossing the sun's face on October 17–18, 1869; but at length discovered that the objects he had been watching with so much attention were locusts.

Mr. Proctor contributes a paper "On the Solar Corona and the Zodiacal Light," with suggestions respecting observations to be made on the total solar eclipse of next December. He exhibits a series of arguments for rejecting the view put forward by Mr. Lockyer that the sun's corona is due simply to atmospheric glare, showing in particular that that portion of the sky on which the corona is projected during total eclipses corresponds to a portion of the atmosphere which is absolutely unilluminated by the sun. He gives reasons for believing the corona to be simply the condensed part of the zodiacal light. Remarking on Dr. Balfour Stewart's recent suggestion that the zodiacal light may be a terrestrial phenomenon, he points out that the trade-wind region (to the illumination of which by electric discharges Dr. Stewart ascribes the zodiacal light) occupies (above the horizon-plane of any station) a lamina shaped like a watch-glass, and the whole of this lamina (in other words, the whole sky) should be illuminated if the theory were correct. Were the zodiacal light caused in this way, a "tongue-shaped slip" only of this lamina would be illuminated; and admitting this to be a possible arrangement at any time, we have yet no explanation of the fact that this slip always occupies a region near the ecliptic, or that it rises and sets with the stars. Among the suggestions put forward respecting modes of observing the eclipse, there is one which, remembering the very short duration of totality, seems to be worth consideration. When totality begins, the eye, accustomed to a brighter light, is unable to accommodate itself to the darkness of totality, nor does totality last long enough to admit of a change in this respect. If, however, the eye were kept in darkness before totality commenced, there seems little doubt that the observer would be able to employ much more effectually the two

minutes of total obscuration. This remark applies not only to general observation, but in an especial manner to those extremely delicate spectroscopic and polariscopic observations which are required in the present instance.

Captain Noble, observing Venus near her inferior conjunction, found the body of the planet projected very distinctly as a dark disc on a light background. "The difference of tint from that of the surrounding sky was evident," he says, "the instant Venus was regarded." This observation, though not new, deserves special attention just now that the nature of the solar corona is being so much inquired into. It shows beyond all possibility of question that there is some light which comes from regions beyond the planet; in other words, that there is just such illumination beyond Venus as we should expect to find if the corona is a solar appendage. It seems amazing that in the face of such evidence—with Venus actually projected as a dark disc on *some* illuminated region beyond her—any astronomer should believe the light of the corona to come from the glare of our atmosphere some hundred miles or so, at farthest, from the earth.

Mr. Browning invites attention to farther changes in the form and colour of Jupiter's belt. The ochreish-yellow which had been so marked during the winter months of 1869 had, on January 31, become much fainter and of a duskier hue, being also confined to the northern part of the equatorial belt, instead of covering the whole of it as had before been the case. On March 10th, he found the tawny-yellow colour again extending over the whole of the equatorial belt, which had become broader than he had ever before seen it. This belt had a very dark band on the south, and a narrower dark band on the north; beyond each of these being a brilliant white belt. It will be interesting when the planet again returns to our skies (towards the end of the year) to observe whether the striking outbreak of colour has passed away or increased. The planet will not rise to a great height on the meridian, but the correcting eye-piece ingeniously contrived by Messrs. Airy and Simms will render observation at low elevations a very different matter from what it used to be.

At Mr. Hind's suggestion, Mr. Plummer, of Mr. Bishop's Observatory at Twickenham, has re-examined the orbit of the comet of 1683. He has been able to show that, instead of the ellipse calculated by Clausen, the orbit of the comet is probably parabolic or nearly so, so that there is very little probability that this famous comet will quickly return to the sun's neighbourhood.

Professor Wolf has continued his researches into the solar spot-period. He finds that the observations made in the years 1864–69 supply clear evidence in favour of his theory that the spot-period is one of $11\frac{1}{9}$ years. But the most interesting part of his communi-

cation is that which has reference to the relation between the variation of the magnetic declination and the frequency of solar spots. In 1859, Professor Wolf had proposed the following formula for this variation (v) at Christiania:—

$$v = 0'{\cdot}0413\, r + 4'{\cdot}921,$$

where r is the "relative number representing sun-spot frequency." The following Table, in which v represents the calculated v' the observed variation, indicates what cannot but be regarded as a very satisfactory confirmation of this formula:—

	1864.	1865.	1866.	1867.	1868.	1869.
v	6'·87	6'·26	5'·64	5'·25	6'·58	8'·39
v'	6·00	5·72	5·70	5·69	6·65	7·82

The observations of the magnetic variation were communicated to Professor Wolf by Messrs. Mohn and Fearnley. It will be seen at once that the minima of the two series closely accord. Doubtless, with the progress of observation, the empirical formula stated above will have to be slightly modified.

Mr. Birt supplies further notes on the visibility of the spots upon the floor of the lunar crater Plato. It seems too difficult to separate the different qualities of vision, the various conditions of the atmosphere, and still more the peculiarities of different telescopes, from the variations of visibility considered by Mr. Birt, to form any satisfactory conclusion on the subject.

Professor Cayley supplies two valuable papers on the geometrical theory of solar eclipses. The mode in which he treats the subject is too rigidly mathematical to admit of being presented in these pages. It may be remarked, however, that in his first paper he discusses, in a most lucid and interesting manner, the problem of determining the stereographic projection of the curve of two dimensions which is the intersection of a cone and a sphere, showing that this projection is a bicircular quartic.

4. BOTANY.

Cross-fertilization.—Dr. Ogle has continued his observations on the various contrivances in the structure of the flower to promote cross-fertilization. The purpose of the nectary is to attract insects; any noticeable irregularity of the corolla is also usually connected with the visits of insects, compelling them, when in search of the nectary, either to impinge on the anthers or on the stigma, and thus carry the pollen from one flower to another. Adrien de Jussieu had remarked the connection which exists between the presence of nec-

taries and the irregularity of the flower, but had not discovered the reason of this connection. To speak of the tufts of hair-like papillæ which are often found on the pistil as collectors of pollen for the purpose of the self-fertilization of the flower, is clearly erroneous; their position shows that their use is the very opposite, serving to sweep the pollen out of the way in order to prevent it from reaching the stigma. Instead of *poils collecteurs*, by which term they are known in French manuals, *poils expulseurs* would be a better name for them. The heads of flowers of the order *Compositæ* usually begin to expand at the circumference, the expansion then extending to the centre. As a general rule the anthers are ripe before the stigmas (*protandry* of Hildebrand); the pollen, therefore, of the inner flowers fertilizes the pistil of the outer flowers; hence the outer flowers of the ray are generally destitute of stamens. Dr. Ogle finds that in *Papilionaceæ* cross-fertilization is the rule; and that the peculiar form of the stamens in *Erica, Vaccinium, Arbutus*, and other genera of the same order, contributes to this end.

Fertilization of Ferns.—Dr. E. Strasburger contributes a paper on this subject to Pringsheim's 'Jahrbuch für wissenschaftliche Botanik.' He commences the account of his experiments by tracing the development of the antheridia, or cells which produce the spermatozoids, from their earliest condition, and states that the growth of their lateral cells presents the first example in the vegetable kingdom of annular cell-formation by division. The new twin cells, a central cell and the annular lateral cells, are distinguished from ordinary cells by the differences of their contents, the inner one being stuffed with granular protoplasm, the outer ones containing at first an almost colourless sap, with a single scarcely discernible nucleus, and a few scattered grains of chlorophyll. After escaping from the antheridium, the spermatozoids, corresponding to the pollen of flowering plants, enter into the central cell of the archegonium, or female organ, by a peculiar twisting motion, and there meet with and fertilize the germ. A large number of the spermatozoids will enter a single cell, forming a kind of chain, but fertilization appears capable of being effected by one only.

Turning of Plants towards the Light.—M. Duchartre contributes to a recent number of the 'Comptes Rendus' an account of a remarkable growth of fungi in a garden at Meudon (Seine et Oise). They were found growing in a hollow place beneath a reservoir kept constantly full of water, in perfect darkness, but in a comparatively high temperature. At the end of September, on the lower surface of this reservoir were found more than 500 individuals of a small Agaric belonging to the genus *Coprinus*. They were all towards the southern part, springing from the roof of the cavity, with their head downwards. The stem of every individual had departed from the vertical by an angle of at least 30°, their

direction being towards the north. The circumstances seem to contradict the prevalent theory that the deflection of plants from the perpendicular is due either to the force of gravity, or to a desire to seek the light.

Sensitiveness of the Mimosa.—In the 'Mémoires de la Société des Sciences Naturelles de Strasbourg,' M. Millardet details some new and elaborate researches on the periodicity of the "tension" in plants, especially in the *Mimosa pudica*, or sensitive plant. The amount of "tension" is greater by night than by day, but undergoes various oscillations of two kinds, which he terms periodic and paratonic oscillations. The periodic oscillations are either long or short, the longer lasting for twenty-four hours, and attaining their maximum towards the end of the night, and their minimum towards the middle of the day; the shorter periodic oscillations lasting about an hour, and occurring both by day and night. The paratonic oscillations are due to differences in light, temperature, moisture, and other causes, and are more pronounced by day than by night; they are intermediate in duration between the longer and shorter periodic oscillations. All these movements occur in both stem and leaves. The motor organs of the leaves consist of tissues which are subject to variations of tension, and the movements are but an expression of these variations.

Variegation and Double-flowering.—It had long been laid down as a maxim by botanists that variegation of the leaves and doubling of the flowers (conversion of stamens into petals) never go together; and although recent writers had doubted the universality of the law, it was difficult to point to any authentic instances of the two phenomena occurring together. Professor E. Morren, of Liége, has, however, set the matter completely at rest by a description in the 'Belgique Horticole,' accompanied by a drawing, of a double wallflower with variegated leaves, which has been successfully grown for some years by M. Rodigas of St. Trond.

Irritability of Stamens.—M. Jourdain * has been trying experiments on the effects of chloroform on the stamens of *Mahonia*, which are excitable like those of the barberry, springing back against the pistil when irritated. When enclosed in a glass bell, in which was placed some cotton, on which a few drops of chloroform had been sprinkled, at the end of one minute the stamens were strongly thrown back as if in a tetanic state, and resisted all attempts at excitation. Exposed again to free air, after eight or ten minutes the irritability reappeared, at first feebly, and completely after the lapse of twenty-five or thirty minutes. If the action of the chloroform is continued for ten or twelve minutes the flower assumes an orange tint, and the stamens do not recover their sensibility on exposure to the air; the next day they become black.

* 'Comptes Rendus,' April, 25.

Acclimatization of Palm-Trees.—In addition to the date-palm and the *Chamærops*, which have long been naturalized on the European shores of the Mediterranean, M. Naudin has succeeded very well with several other kinds at Collioure, in the Pyrenees, notwithstanding the exceptionally unfavourable character of the winter of 1869–70. The severe cold of the last week of December, when the thermometer descended to − 4°, and in some localities even to − 6° C., was fatal to only one species. The extraordinarily heavy fall of snow which took place in January, lasting for forty-four hours without intermission, was expected to destroy the young trees altogether. After, however, they had been entirely covered up with snow for nine or ten days, so that the boughs were completely flattened, when the thaw came they almost immediately recovered their former position, even the green colour of the leaves not being injured. The same fall of snow caused a fearful amount of destruction among the olives and cork-oaks.

Mimetic Plants.—At a recent *soirée* of the Linnean Society a very interesting set of foliage-plants was exhibited by Mr. W. Wilson Saunders, arranged in pairs, the plants of each pair bearing such a striking resemblance to one another in the general character of the foliage, and even in the venation of the leaves, as to be with difficulty distinguishable from one another, and yet belonging to entirely distinct natural orders, not in any way related to one another. Mr. Saunders states that none of the plants were grown for the purpose, but were selected on the spur of the moment from his collections; and he has little doubt that if attention were drawn to the subject, such a collection might be indefinitely increased.

Parasitic Fungi.—In several recent numbers of the 'Zeitschrift für Parasitenkunde,' edited by Dr. E. Hallier, instances are recorded of diseases of the ear resulting in deafness being caused by minute parasitic fungi. The most certain cure appears to be the external application of spirits of wine.

Recent and Fossil Copal.—At the meeting of the Linnean Society, held May 5th, Dr. J. D. Hooker read a communication from Dr. Kirk, Her Majesty's Vice-Consul at Zanzibar, on the distinction between the recent and fossil states of the resin known in commerce as Copal. One characteristic by which fossil copal is known from the recent resin is the so-called "goose-skin." Dr. Kirk has ascertained that the fossil copal shows no trace of this goose-skin when first dug out of the earth, but that it makes its appearance only after cleaning and brushing the outer surface. Both descriptions often contain imprisoned leaves, flowers, and insects in a beautiful state of preservation; but the fossil variety is clearer and more transparent. Captain Grant states that the true copal gum-tree is a climber reaching to a great height among the forest trees, finally becoming completely detached from its original root, when the copal exudes from

the extremities of these detached roots. Large pieces of the resin fetch a very high price even in that country.

New Species of Jalap.—Mr. Daniel Hanbury contributes to the 'Journal of the Linnean Society' a description of a hitherto undescribed Convolvulaceous plant, which he names *Ipomæa simulans*, being the plant the root of which furnishes the article known in commerce as Tampico Jalap. It is obtained from Mexico, and has been extensively brought into the market; and though it is less rich in resin and less purgative than true jalap, yet, on account of its lower price, it has found a ready sale, chiefly in the Continental trade.

5. CHEMISTRY.

It has long been a disputed question whether a small quantity of phosphorus improves or injures the mechanical properties of steel. M. L. Gruner has carefully examined this subject, and has arrived at the result that phosphorus present in steel in a quantity of from 0·002 to 0·003 causes the metal to be rigid; it tends even to increase the elasticity and the resistance to breaking, but does not modify the hardness. Such steel, however, is wanting in real strength and toughness; it is brittle (*aigre*), that is to say, does not withstand shocks. The general result is, therefore, that even very small quantities of phosphorus present in steel do not only not improve, but certainly deteriorate, its good qualities. Dr. Salet, the chief assistant to Professor Wurtz, has arranged an ingeniously constructed apparatus to detect the smallest possible quantity of phosphorus in iron and steel, by means of the spectrum produced by the combustion of the hydrogen obtained by the action of chlorhydric acid on the metal.

Since the internal use of amylic alcohol, even in small quantities, is very deleterious, the means of rapidly testing for its presence in spirits and alcohol (either for pharmaceutical or scientific use) is of importance. The suspected alcohol is poured into a burette, mixed with its own bulk of rectified and pure ether, and also its own bulk of water, and the mixture gently shaken; the ether, on becoming separated from the rest of the fluid, floats to the top, containing in solution the whole of the amylic alcohol which might have been contained in the alcohol or spirits under examination. The ether is removed by a pipette, and on leaving it to spontaneous evaporation, will leave behind the amylic alcohol, readily detected by its offensive odour.

The absence of oxygenated water from snow which fell at Rouen has been shown by M. A. Hozeau. He has tried some very careful experiments to detect the presence of peroxide of hydrogen in water

obtained from snow, care being taken to prevent the loss or decomposition of the peroxide alluded to. The author's opinion is that, since the experiments made at Kasan undoubtedly proved the presence of the peroxide of hydrogen in snow-water, there may exist an essential difference, caused by the locality where it falls. Kasan is situated almost in the centre of the Russian empire, far away from any seas or oceans.

On the other hand, Professor H. Struve has ascertained the presence of peroxide of hydrogen in air. His chief results are, (1) peroxide of hydrogen is formed in air simultaneously with ozone and nitrate of ammonia, and is condensed in the rain-water; (2) peroxide of hydrogen, ozone, and nitrate of ammonia, are intimately connected together; (3) the change which the so-called ozone-paper undergoes when exposed to air is due to the joint action of ozone and peroxide of hydrogen; (4) peroxide of hydrogen does not decompose solution of iodide of potassium with separation of free iodine; (5) free carbonic acid decomposes the solution of iodide of potassium, causing the formation of carbonate of potassa and free hydriodic acid; (6) when the peroxide of hydrogen is present along with carbonic acid (acting as just alluded to), iodine is separated; (7) the best and most effective reagent for the detection of small traces of peroxide of hydrogen is oxide of lead, since puce-coloured peroxide is formed.

According to J. Jouglet, nitro-glycerine, dynamite, iodide of nitrogen, chloride of nitrogen, and some other similar compounds, explode the very moment they are brought into contact with ozone; so that, for instance, a drop of nitro-glycerine, introduced into a vessel containing ozone, causes an instantaneous explosion. Picrate of potassa gunpowder, and ordinary gunpowder, are slowly decomposed by ozone, a decomposition which, as regards the last-named substance, takes several weeks before it is perceptible.

Under the name of Albolith, Dr. Riemann prepares a cement chiefly consisting of magnesia For this purpose, the magnesite of Frankenstein (Silesia) is ignited in retorts similar to those used for gas-manufacture; and after the mineral (a native carbonate of magnesia) has been ignited, it is mixed with silica and some other substances. This mixture has the property of yielding, with moderately concentrated solutions of chlorides (for instance, chloride of magnesium), an extremely plastic, but, on drying, a very hard material, excellently adapted for use as cement for stucco and ornamental work, and instead of gypsum.

In a research on Isinglass, J. L. Souberain states that the different varieties of this article, as met with in the trade, may be recognized as follows:—Russian isinglass dissolves rapidly and instantaneously in hot water, leaving hardly ever more than at most 2 per cent. insoluble residue; Bengal isinglass dissolves readily,

but leaves from 7 to 13 per cent. of residue. The taste of Russian isinglass is pleasant and sweet; it yields a very firm gelatine, which is perfectly transparent. The Bengal, or Indian kind, often has a fishy taste, and the gelatine it yields is not clear. The Brazilian isinglass yields an opaque, milky-looking gelatine, and its taste is acrid. China isinglass is a rare article in the European markets.

An important reaction in synthetical chemistry has been published by Dr. E. Royer, who has effected the formation of formic acid from carbonic acid. The author states that, while submitting to the action of a current of electricity an aqueous solution of carbonic acid, the latter was simply converted into formic acid by the addition of hydrogen.

Owing to the fears of a quinine famine expressed some years ago, great efforts were made to introduce the cultivation of cinchona trees in numerous new localities. We have recently heard of the first importation of cinchona bark from Java, a quantity of some 930 lbs. of this bark having been exported from Java to the Netherlands. According to analysis made by Dr. B. Moens in Java, this bark contains from 2·4 to 7·5 per cent. of alkaloids, of which quantity 0·59 to 3·67 is quinine. The loss of weight occasioned by the drying of the bark has been found to amount to 66 per cent. There is every prospect that within some six or seven years hence Java will largely export this drug; and the cultivation of the cinchona trees is also to be extended to Sumatra, Celebes, and the Moluccas.

Dr. Loew has made known a fact which renders still more probable the Hydrogenium theory of the late Professor Graham. The researches of Graham went to show that hydrogen could be alloyed with palladium, and that it was also contained in meteoric iron. He condensed the hydrogen in the palladium, and came nearer proving its metallic character than any other person had done. Dr. Loew has succeeded in combining hydrogen with mercury. He takes an amalgam composed of not more than 3 or 4 per cent. of zinc, and shakes it with a solution of bichloride of platinum; the liquid becomes black, and a dark powder settles to the bottom. The contents of the flask are then thrown into water and hydrochloric acid added to dissolve the excess of zinc. The amalgam of hydrogen and mercury at once forms in a brilliant voluminous mass, resembling in every way the well-known ammonium amalgam. It is soft and spongy, and rapidly decomposes, but without any smell of ammonia. The hydrogen escapes, and soon nothing but pure mercury is left in the dish. The experiment appears to show that an amalgam of hydrogen and mercury can be formed, and that hydrogen is really a metal.

Now that the analysis of air—physical and chemical—is attracting so much attention, it may be of some interest to know what

substances the New York Metropolitan Board of Health found in the air of the opera-houses. Over one hundred specimens of the particles floating in the air, and falling as dust, were collected on plates of glass, and examined under the microscope. The proportions of the different ingredients varied, but the same substances were found in all the specimens. The composition of the matter subjected to the microscope was as follows:—The dust of the streets in its finer or coarser particles, according to the height at which it had been collected, with a large proportion of organic elements; particles of sand, quartz, and feldspar; of carbon, from coal-dust and lamp-black; fibres of wool and cotton of various tints; epidermic scales; granules of starch of wheat; the tissues of plants, mainly the epidermic tissue, recognized by the stomata or breathing pores; vegetable ducts and fibres, with spiral markings; vegetable hairs or down, either single or in tufts of four or eight, and of great variety, and three distinct kinds of pollens. Fungi were abundant, from mere micrococcus granules to filaments of mould. When water was added to a portion of dust from whatever source, and exposed in a test-tube to sunlight or heat for a few hours, vibriones and bacteria made their appearance, and the fungous elements sprouted and multiplied, showing that they maintained their vitality, and proving that the germs of fermentation and putrefaction are very widely diffused. In connection with this subject, it is right to mention here that Mr. Samuelson performed a similar series of experiments six years ago, on dust from all parts of the world.*

All lecturers who have tried to float and then ignite an explosive balloon will be glad to know the following easy means of effecting this difficult but striking experiment devised by Mr. Patterson. At first the author tried the india-rubber balloons of the toy-shops. From various causes they had failed; but the chief difficulty was doubtless the tension which made it difficult to secure the gases. Recently the author's attention has been directed to the collodion balloons, obtainable from the philosophical instrument makers, believing that they would suit well, both on account of their lightness, and on account of the fact that they would wholly disappear on ignition. After a number of trials he has found them to succeed admirably. The method adopted is as follows:—

A fuse of filter-paper, about 1 inch long and $\frac{1}{2}$ inch broad, is gummed to the side of the balloon near the mouth, and allowed to dry. The latter is then filled with a mixture of $2\frac{1}{2}$ volumes of hydrogen gas and 1 volume of oxygen, the mixture being prepared in a separate vessel. The mouth of the balloon is at once tied with a piece of thread to increase the force of the explosion. When the balloon is ready to ascend, a drop of the so-called "Greek fire"

* See 'Quarterly Journal of Science,' July, 1864.

(that is, a solution of phosphorus in carbon disulphide) is placed on the filter-paper; the thread is cut and the balloon left to itself. In the course of half a minute or so the explosion ensues. It is necessary to have an excess of hydrogen in the mixture, because exosmose takes place so rapidly that, by the time of ignition, the volume of that gas is sensibly reduced.

6. ENGINEERING—CIVIL AND MECHANICAL.

In our last number we gave, under the above heading, a brief account of narrow-gauge railways, which, during the period therein referred to, had engaged considerable attention both in this country and in Russia. The necessity for improving the means of local transit has, since then, continued to receive the consideration of all most interested in the question; and a "Tramways' Bill" has recently passed through the Legislature, in which provision is made for facilitating the construction and laying of tramways on common roads.

Street Tramways.—Tramways for passenger traffic have for some time past been in operation in New York, Boston, Washington, New Orleans, and they are becoming general in all the more important towns of the United States. Paris, Genoa, Vienna, Copenhagen, and Brussels, have all their tramways for passenger traffic, and they have also, for some years, existed in Liverpool along the Dock sides. Some years since iron rail tramways were introduced into London, but after a short trial they were ordered to be removed in consequence of the obstructions they caused to ordinary vehicles. At the East End of London a granite tramway has been in existence for many years, extending from the western end of the Commercial Road East to the West India Dock; and in a circular by Mr. J. B. Redman, dated in March last, on the subject of Metropolitan Tramways, it is stated that "practically the tramway is in as efficient working a state as it was twenty years back." The late Mr. Walker conducted certain experiments with granite tramways in 1829, which showed that a powerful draught-horse could draw a load equal to 30 tons upon a level, at the rate of four miles an hour; and in his report on the subject he said, "The friction is not more than upon the best constructed edge railways. I consider that the greater size of our wheels, and there being no flange, compensates for the roughness of the stones (from their being newly laid) as compared with an iron railway."

Whilst fully alive to the advantages of tramways for lessening friction, attention has not yet been sufficiently given in this country to the improvement of our macadamized roads by rolling; and now

that steam road-rollers have been brought to such perfection, the operation is much simplified. Road rolling has for more than a quarter of a century been officially applied over the whole extent of the French and Prussian roads, which are kept up under centralized State superintendence, and perhaps one of the strongest arguments in its favour may be given in the words of the surveyor of the roads near Coblentz, in Prussia, who has observed that as "everywhere in Prussia and in France the highways are rolled, if the systems were not good the expense would not be incurred." Space will not admit of our entering further into this subject now; the whole question has recently been very ably and fully discussed by Mr. F. A. Paget, C.E., in a pamphlet entitled 'The Economy of Steam Road-rolling,' to which we would refer our readers for further information on this head.

The recent movement in favour of tramways in London has resulted in the construction, by the Metropolitan Street Tramways Company, of two short lines, together about four miles in length, the one at Brixton and the other between Whitechapel and Bow. The tram adopted by this Company, and which may class, perhaps, as the best in form hitherto introduced for the purpose, consists of an iron groove fixed level with the surface of the paving, on which the flange of the omnibus wheel travels. The lines are double, and between them as well as in the space between the trams, and strips on either side of about 20 inches wide, the ground is paved with granite sets. The plan of the road, which consists of longitudinal wooden sleepers laid upon concrete, admits of the repair of the tramway, by lifting up lengths of tram and sleeper, without breaking up the road beyond the width of the tram (four inches), and a few stones here and there to undo the fastenings.

Single Rail Permanent Way.—Amongst other novelties of recent introduction, and which come under the category of "Tramways," we may mention two projects for single-line rails. The one by Mr. W. J. Addis, of Tannah, near Bombay, has already been put into practice in India, where it is reported to work very favourably. In this case the rail is intended to be laid down either upon any existing line of road, or on roads made especially for the purpose of a tramway. One of the advantages claimed for this kind of line is that ordinary carts may run upon it, the only necessary alteration being the addition of a central wheel, or wheels, according to the length of the vehicle; the additional wheels being attached to the bottom of the platform of the carts, and having a flange on either side to prevent any moving off the rail. These wheels work on a swivel attached to a screw, by means of which the ordinary side-wheels are raised slightly off the road, so that the whole weight of the vehicles rests upon the central rail.

The second single-rail project to which we have referred was

designed by M. J. Larmanjat, and was first carried out by him in a short trial line, constructed between Raincy and Montfermeil in the summer of 1868. According to M. Larmanjat's system, the tramway is constructed with a single central rail, and along a good road this constitutes the whole of the permanent way. The locomotive employed to haul the trains has four wheels, the two driving wheels, placed on either side, resting on the ordinary surface of the road, and a leading and trailing wheel, having grooved peripheries, and which are situated on the centre line of the machine, bearing upon the central rail. The carriages have also four wheels, arranged in a similar manner, but whilst in the engine the greater weight rests on the side driving wheels, in the case of the carriages the adjustment of the springs is such that the chief weight rests upon the wheels running on the central rail, the other wheels merely serving to steady the vehicle.

Wire Tramway.—Another improved method of cheap tramway construction is found in Hodgson's Wire Tramway system, a specimen of which, five miles in length, has recently been constructed in the immediate vicinity of Brighton. One respect in which this differs from other tramway projects is its unfitness for passenger traffic, it being principally applicable for the conveyance of mining produce and goods generally. Hitherto it has mostly been employed by the French beet-root growers to carry the roots from the field to the storehouses. This tramway consists of a strong iron wire, running over rollers supported on posts, having brackets extending on either side. The greatest length to which one rope line is usually applied is five miles, and a succession of such lengths would be required for any greater distance. At each end of the line is placed a horizontal wheel, around which the rope turns, and at one end is placed an engine for giving motion to the wire. The truck employed consists of a kind of shallow box without a lid, suspended from the wire by means of a bent arm, so arranged that the saddle which rests on the wire is immediately over the centre of the truck. The rope being put in motion, these trucks are caused to run upon it, and are carried forward with it. Where a long line is required, suitable arrangements are made by which the trucks run from one wire on to the next, and so on.

Meetings of Societies.

Institution of Civil Engineers.—Space will not admit of more than a passing remark on the most important papers read at this Institution. On 8th March, Mr. D. M. Fox read a "Description of the Line and Works of the San Paulo Railway in the Empire of Brazil." The line is 88 miles in length, and was constructed at a total aggregate cost of 1,861,667*l.* It runs over low swampy

ground for the first 13½ miles, and then rises to a height of 2500 feet by means of inclined planes of 1 in 10, worked by stationary engines. From this summit, for a distance of 68 miles, the line crosses a succession of short ridges and valleys, with occasional deep cuttings and embankments A description of "The St. Pancras Station and Roof, Midland Railway," was read by Mr. W. H. Barlow on 29th March. As this work has already been noticed in this Journal, we shall not give any further account of it now. "The Maintenance and Renewal of Railway Rolling Stock," by Mr. R. Price Williams, on 12th April, is a most important and interesting paper, but it is so filled with statistics and figures as to render any short abstract impossible. On May 3rd, Mr. George Berkley read a most important paper "On the Strength of Iron and Steel, and on the Design of parts of Structures which consist of those materials." And on 24th May two papers were read, the one by Mr. George Fowler, "On the Relative Safety of different modes of Working Coal," and the other, "On Coal Mining in Deep Workings," by Mr. Emmerson Bainbridge.

Institution of Mechanical Engineers.—At a general meeting of this Institution, held on 28th April, amongst other business a paper was read "On a Steam Road-Roller." This roller was 25 tons weight, and 9 feet wide; it could roll an area of 300 square yards per hour, with a consumption of coal of about 1 cwt. per hour. The adhesion was found sufficient for gradients as steep as 1 in 9.

South Wales Institute of Engineers.—On the 5th May, at the usual general meeting of this Society, held at Newport, Monmouthshire, discussion was resumed on Mr. J. Brogden's paper "On the Comparative Merits of large and small Trams for Colliery Use," and "On Bernard's Coal-Washing Machine." A paper was also read "On the Application of Blast of a High Temperature to Blast Furnaces of moderate Elevation," by Mr. Thomas Whitwell.

The New York Society of Practical Engineers.—A well-timed paper was read on 20th April last by Mr. C. Williams, "On the Old and New Methods of City Transit," in which a history was presented of the various methods from time to time attempted to facilitate locomotion in cities and towns; and the paper wound up with a description of a method of applying compressed air to locomotive purposes.

Literature.

'Report on the Maritime Canal connecting the Mediterranean at Port Said with the Red Sea at Suez,' by Captain Richards, R.N., F.R.S., Hydrographer to the Admiralty, and Lieutenant-Colonel Clarke, C.B., R.E., Director of Engineering and Architectural Works, Admiralty. This report has been published by Govern-

ment, and coming as it does from officers of such high authority, after a personal inspection of the Canal, it possesses a peculiar national interest not to be found in similar works by independent individuals on the same subject.

'Principles and Construction of Machinery; a Practical Treatise on the Laws of the Transmission of Power, and of the Strength and Proportions of the various Elements of Prime Movers, Mill-work, and Machinery generally; arranged for the use of Students, Engineers, and Practical Mechanics,'* by Francis Campin, C.E. The aim of the author is stated in the preface to have been "in the first place to explain the fundamental theories of mechanism in the clearest and briefest manner, so as to impress upon the mind *general principles*, not special cases, and then to show the practical developments of such theories, care being taken to arrange the matter as to try the faculties of the mind as little as possible." This text appears to have been well adhered to, and the result has been the production of a book calculated to prove of great use to the classes for whom it has been written.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society and Notices of recent Geological Works.)

In the 'Philosophical Transactions'(1869), p. 445, will be found a most valuable contribution to the Fossil Flora of North Greenland, being a description of the plants (collected by Mr. Edward Whymper during the summer of 1867) by Professor Oswald Heer.

The greater part of the fossil plants which have been brought from Arctic regions have come principally from one locality, Atanekerdluk, in (lat. 70° N.) North Greenland. Here, however, they occur in such profusion that we are able, to some extent, to restore the ancient flora, and deduce most important conclusions as to the former condition and climate of this high northern region. The fossil plants brought home by M'Clintock, Inglefield, and Colomb, and deposited in Dublin and London, were found at this locality, also the very rich collection made by Mr. Olrik (formerly Inspector of North Greenland), and now deposited at Copenhagen. These materials were found upon examination to contain 105 species of plants. Of some the leaves, fruits, and seeds were observed, so that an absolute determination of their species was rendered possible; while of others merely the leaves, and of these, at times, only fragments, were discoverable. Of these latter therefore the identifications cannot be considered as final.

* London: Aitchley and Co.

Mr. Whymper's collection contains, on the whole, 80 species of plants from North Greenland; 32 of these are new for this flora, and 20 are quite new. The Miocene plants of North Greenland have thereby reached the number of 137 species, and those of the Arctic Miocene flora 194. Of these 137 species from Greenland, 46 agree with those of the Miocene of Europe. The systematic position of a number of plants from North Greenland is as yet uncertain; but the number positively identified is so large, that it enables us to give a sketch of its Miocene flora. Of the fossil plants from Disco Island there are 14 species: of these, *Aspidium Meyeri*, *Sequoia Couttsiæ*, *Platanus Guillelmæ*, and *Magnolia Inglefieldi* are most widely distributed. The plane and the *Sequoia* are the commonest trees; to these may be added a *Widdringtonia*, a *Liquidambar*, and a *Magnolia* with large evergreen leaves. Two cones of this *Magnolia* having been obtained, they corroborate the determination of this tree originally effected by means of the leaves alone.

A *Dryandra*, an *Aralia*, and a *Paliurus* probably constituted the brushwood of the forest, whilst several species of ferns covered the ground. The *Phragmites* and the *Sparganium* point to the existence of a river or a lake. Of the 73 species from Atanekerdluk, 25 are new. Five of these are found in the Miocene flora of Europe, *viz.*:—*Poacites Mengeanus*, *Smilax grandifolia*, *Quercus Laharpii*, *Corylus insignis*, and *Sassafras Ferretianum*. The oaks appear very frequently at Atanekerdluk. The southern limits have been determined as follows:—Six species stop at the Baltic coast; ten occur in Switzerland; seven in Austria; four in France; seventeen in Italy; six in Greece; four are common to North Greenland and Bovey Tracey in Devon. It is certainly very interesting to find so many species extend to Italy and Greece. Almost all these may be referred to the country situated between these two extreme limits, and we thereby see that our knowledge respecting the Miocene flora of Europe, at least the forest-plants, is no longer so imperfect as heretofore. Dr. Heer's paper contains descriptions of all the species collected, and is illustrated by eighteen 4to plates of the fruits and leaves determined.

On *Palæocoryne, a genus of Tubularine Hydrozoa from the Carboniferous Formation*.*—This new and remarkable little fossil, representing the first of its class, is introduced to the Royal Society under the guarantees of Dr. P. Martin Duncan, F.R.S., &c., Sec. Geol. Soc., and Henry M. Jenkins, F.G.S., Sec. Roy. Agric. Soc. It was obtained from the lower shales of the Carboniferous limestone series of Ayrshire and Lanarkshire, which is very fossiliferous in many places, and is also remarkable for the perfect condition in which the organic remains found therein have been

* 'Phil. Trans.,' 1869, p. 693.

preserved. In these shales numerous small pedunculated radiata (whose external appearance differs from that of any extinct organism hitherto discovered) are found, usually attached to the margins of the polyzoarium of *Fenestellæ*, or in a more or less fragmentary condition amongst the small pieces of broken Polyzoa and Crinoid stems which compose the fossiliferous layers of the shale.

The attachment is by a dactylose base, which, when broken or cut, is proved to be cellular internally. The base contracts as it increases in height, and is continued upwards in the form of a cylindrical stem, which is faintly enlarged in its middle portion, and which is surmounted by a symmetrical structure resembling a reversed obtuse cone, the margin of whose base is prolonged into several tentacular processes, which are arranged in one whorl, and are long, slender, and tapering. The upper surface of the body is granular, and the stem is ornamented with longitudinal flutings and minute processes. The general appearance is that of a long straight-armed star-fish reversed and fixed on a stiff stem with an expanded base. The authors enter carefully into the minute anatomy; they then proceed to show why it is inadmissible as an Echinoderm, a Polyzoan, or a Zoantharian, and finally, through having so remarkable a calcareous investment, they show that by the aid of the anomalous living genus *Bimeria* (Wright) they are able to overcome the difficulty and refer it to the Hydrozoa. It is therefore placed in the class Hydrozoa and in the Order *Tubularidæ*, of which it will constitute a new family and at present a singular genus. Two species are described and figured by the authors. It is extremely probable that other new and interesting forms may be discovered in these shales, but hardly possible that anyone will be able, like the authors of this paper, to light upon a new class of fossils.

Mr. W. T. Blanford, F.G.S., late Geologist to the Abyssinian Expedition, has given us the result of his observations on the Geology and Zoology of Abyssinia, made during the progress of the British Expedition to that country in 1867–68.*

The author was detached from the Geological Survey in India in 1867, and started for Abyssinia.

The formations met with throughout the region traversed were:—1. Recent: consisting of soils of the highlands, including "regur," or cotton-soil, similar to that found in India, and alluvial deposits on the coast. 2. The volcanic series, which skirts both coasts in the southern portion of the Red Sea. This group, which is but poorly developed on the west coast of Annesley Bay, Mr. Blanford proposes to call the Aden Volcanic series. 3. Trappean series. This grand collection of beds, which forms the Abyssinian highlands, including Magdala and the Ashangi groups, consists of two divisions,

* Macmillan and Co.: London, 1870.

which are unconformable to each other, the former (the Magdala group) consisting of trachytes and dolerites, and the latter (the Ashangi group) entirely composed of dolerites of great thickness and bedded volcanic rocks, lavas, and ashes. Through this Trappean series, near Bethor, not far from Magdala itself, the Jitta River has cut its way and now runs at a depth of 3500 feet, in a valley probably more than a mile in width. The sides are extremely steep, often perpendicular. The beds on both sides appear exactly to correspond. A well-marked river-terrace, half-way down, indicated on both sides of the stream, records the fluviatile origin of the gorge. Of all the grand scenery, says Mr Blanford, met with in Abyssinia, none equalled this wonderful gorge. His descriptions remind one of the Grand Cañons of the Colorado River. 4. "The Antalo limestone" is of Oolitic age, and contains *Ceromya similis, Trigonia costata,* and other characteristic fossils, reminding one strongly of British forms. 5. "Adegrat sandstone," a massive formation, occupying a very extensive area in northern Tigre, and perhaps representing the coal-bearing rocks known to exist north-west of Lake Dembea, but yielding no fossils. 6. Metamorphic rocks of various mineral character, with a general north and south strike, due to pre-existing cleavage.

The author describes the scenery as being almost everywhere most strikingly beautiful, now bold and romantic, now resembling the undulating character of Western England. Some of the illustrations are very remarkable and striking, the plateau-like disposition of the tops of all the hills reminding one strongly of the Sinaitic peninsula, as if the same meteoric agencies had carved out the valleys from an originally highly elevated, but unbroken plain. The recent natural history part of the work is ably dealt with by Mr. Blanford, and the book will well reward the zoologist, and even the ordinary reader of travels.

Several Geological Survey Memoirs have made their appearance in the present quarter. From the Geological Survey of England and Wales we have,—'A Memoir on the Geology of the Carboniferous Limestone, Yoredale Rocks and Millstone Grit of North Derbyshire and adjoining parts of Yorkshire,' by Messrs. A. H. Green, C. Le Neve Foster, and J. R. Dakyns, with an Appendix on the Fossils by R. Etheridge. Secondly, 'The Triassic and Permian Rocks of the Midland Counties of England,' by Edward Hull, F.R.S., &c.

From the Indian Geological Survey we have Part I. vol. vii. of the Memoirs, 'On the Vindhyan Series, as exhibited in the Northwestern and Central Provinces of India,' by Frederick R. Mallet, F.G.S.; No. I. of Records (1869), 'The Valley of the Poorna River, West Berar,' by A. B. Wynne, F.G.S., &c.; also Part I. vol. viii. of the 'Records of the Indian Survey for 1870.' In this last-men-

tioned publication is Dr. Oldham's Report for 1869, in which the Director sets forth not only the labours accomplished by his comparatively small staff, but also sketches out their projected labours for 1870. In speaking of the enormous area which the Indian Survey has to traverse, Dr. Oldham remarks, "I have always found it exceedingly difficult to lead to a just conception of the immensity of the areas we have to deal with in this country, and it may be useful to draw a comparison here which may tend to a realization of the facts. The small map, which accompanies Mr. Mallet's Report (a reduction from the larger scale maps used in the field), the title of which we quoted above, represents an area quite as large as England and Wales; while all the lines of geological division and subdivision shown on it have been actually traced out by detailed examination.

The previous Part of the Memoirs (the last Part of vol. vi.) contained also a geological map of quite as extended an area; that is to say, geological maps and reports have been published within twelve months, exhibiting the structure of a country larger in area than the whole of Great Britain and Ireland; and to this should be added that the maps relate to a country, regarding the structure of which nothing trustworthy was known previous to the Geological Survey commencing their labours.

Two other papers appear in the same Part, namely, "Notes on the Geology of the Neighbourhood of Madras," by R. Bruce Foote, F.G.S., and "On the Alluvial Deposits of the Irawadi, more particularly as contrasted with those of the Ganges," by W. Theobald, jun., Esq.

Under the title of 'Eminent Living Geologists,' the Editor of 'The Geological Magazine' has published an account of Professor Adam Sedgwick, of Cambridge, and Mr. G. Poulett Scrope, F.R.S.: both these gentlemen have attained to the highest honours in geological science, and have contributed largely towards its literature. The former, as the Woodwardian Professor of Geology in Cambridge, has delivered fifty-two courses of lectures in the University; the latter is the well-known author of the 'Volcanoes of Central France,' published so long ago as 1827, and of many other works on Volcanoes, &c. Both notices are accompanied by well-executed portraits.

In the same journal Professor Huxley gives us the results of his examination of *Palæotherium magnum*;* Professor T. Rupert Jones, the South Wales *Entomostraca*;† Professor de Koninck, of Liège, some new Palæozoic Echinoderms;‡ Professor Harkness, of Elephant-remains in Ireland.§ Mr. James Croll accounts for the Boulder-clay of Caithness; Mr. Charles Lapworth explains the Geology of Galashiels; Mr. Henry M. Jenkins, the Geology of

* P. 153. † P. 214. ‡ P. 248. § P. 253.

Belgium; Mr. Allport writes on the Basaltic Rocks of the Midland Coal-field; The Rev. T. G. Bonney, on *Pholas*-Burrows; Mr. J. W. Judd, on the use of the term Neocomian, &c., &c. There are also the usual Geological Notices, Reports, &c.

'The Quarterly Journal of the Geological Society' contains papers by Messrs. R. Tate and J. S. Holden, on the iron ores associated with Basalts in the North-east of Ireland; Principal Dawson, of Montreal, on the Structure of *Sigillaria*, and on some new Animal-remains from the Carboniferous and Devonian of Canada.

Mr. J. W. Hulke makes known a new Crocodilian skull from Kimmeridge Bay, Dorset, which he has named *Steneosaurus Manselii*; and some teeth associated with two fragments of jaw, from the same locality, which he has provisionally named *Euthekiodon*.

Mr. Etheridge describes the Geological Position and the Geographical Distribution of the Reptilian or Dolomitic Conglomerate of the Bristol area, from which were obtained the remains of *Thecodontosaurus* and *Palæosaurus*, Dinosaurian reptiles about which more has yet to be made known.

Mr. Wilson sketches out the surface-geology of Rugby, and Mr. Lloyd does the same for the Avon and Severn Valleys.

Mr. Moore's (postponed) paper upon Australian Mesozoic Geology and Palæontology, makes us acquainted with a large number of new Australian fossils (chiefly obtained from erratic blocks, of the parentage of which nothing is at present known). These remains are, however, many of them very unsatisfactory for purposes of determination. Mr. Moore considers they are comparable with our Lower Lias types. The part is a bulky one, and is illustrated by nine 8vo and two 4to plates.

The Ancient Relations of Land and Water.—Professor Huxley's address last quarter to the Geological Society has such vast importance for the zoologist that we must allude to it here. It forms the starting-point of a scientific study which hitherto has been suffering for want of some sound and comprehensive speculation to which workers may bring their facts, which may be taken as the basis of operations, and enlarged, modified, and improved in various directions. The question suggested by a consideration of the distribution of living organisms on the earth's surface is, not only what forms have we in this or that locality, but *how* did they get there? Did A come with B or with C; did they all come together or separately? It is this examination of the faunæ and floræ of various regions which Professor Huxley enters on, and broadly sketches out the various ways in which in past times the terrestrial animals of the different areas at present recognized may have arrived there. By fully following out this line of study, we may one day be able to assign its proper history to every species of animal and plant, and to trace the wan-

derings of its forefathers from one region to another, and their gradual modifications of form. In looking at our English fauna, we may hope to recognize certain forms as belonging to our area from Palæozoic times, others as dating from Mesozoic, others again as Eocenic, others as Miocenic or later; in some cases we shall assign such an age to the order or genus, and a later age to the specific modification. Professor Huxley conceives that distinct provinces of the distribution of terrestrial life have existed from the earliest periods—earlier than those of which we have any record. Whilst in the dry land of our own area during Carboniferous times *Amphibia* existed, in some other terrestrial provinces of that period *Birds*, *Reptiles*, and *Mammalia* may have been developing. The Permian epoch marks the beginning of a new period, and during the Trias dry land existed in North America, Europe, Asia, and Africa, as it does now. The mammals, birds, and reptiles developed in the preceding epoch spread into this great continental area called Arctogæa. Depression then commenced in parts, and special developments occurred in various regions. At the early part of this period, Professor Huxley conceives Australia to have been separated and to have remained dry land ever since. The discovery of the remarkable Australian Ganoid since his address, confirms his conclusion. The Mesozoic continent was probably continued across the Pacific area to what is now the province of Austro-Columbia, the characteristic fauna of which dates from this period. At a later part of the Mesozoic period, upheaval of the Atlantic shore and depression of the Pacific caused a westward movement of the Vertebrate fauna which took possession of new lands and increased in extent up to the Miocene epoch, from which period we may clearly trace all the Mammalian forms characteristic of the great continental area of our present world—exclusive of South America, Australia, and New Zealand. From the Devonian period to the present day, the four great oceans—Atlantic, Pacific, Arctic, and Antarctic—may have occupied their present positions and only incessantly changed their channels of communication and coast-lines.

The attempt in this address to follow back the origin of Vertebrate forms of life, needs only to be succeeded by similar efforts with regard to Invertebrate groups, and more especially as to plants, the same method of comparing present distribution and past, as far as it is yet known, being used, and we shall ultimately attain most valuable conclusions as to both Geological and Biological history.

The palæontology of the greater part of the earth has yet to be investigated in order to bring light on this matter.

8. METEOROLOGY.

The most important paper which we have to notice in this number is one by Dr. Julius Hann, "On the Climate of the Upper Regions of the Alps," which appears in the 'Journal of the Austrian Meteorological Society.' The Swiss stations are situated in many instances at considerable heights above the sea. Five of them are at a level exceeding 6000 feet. The station of Hoch Obir, in Carinthia, is at a similar height. However, the information derived from these points gives us hardly any knowledge of the climate prevailing above the snow-line, and the difficulties which presented themselves in the way of obtaining accurate observations from such an elevated region seemed almost insurmountable, until they were overcome by M. Dollfuss. This gentleman succeeded in persuading three Swiss guides to spend an entire year, from August 1865 to August 1866, on the Pass of St. Theodule, under the Matterhorn. The level of this station is all but 11,000 feet above the sea.

The barometrical observations were made three times a-day, while those of temperature, wind, and weather, were recorded eleven times daily.

The first point on which Dr. Hann touches is the extreme of cold registered, which he finds to be only 6°·5 F. The winter of 1865–6 was a warm one, but still the temperature just cited is unexpectedly high for so elevated a station, considering that much greater cold has been experienced at lower stations in Europe nearly on the latitude of the Pass in question, *e. g.*, – 12°·5 at Geneva in January, 1838, and – 20° at Prague in 1830. We need not refer to the intense frost felt in corresponding latitudes in America, where, in the State of New York, the mercury has been known to freeze.

The self-registering minimum thermometers, which have been placed on the summits of so many mountains by the members of the Alpine Club, have not yielded results at all commensurate with the labour of depositing them in their resting places and subsequently reading them, so that we are driven to the ordinary records at high levels to find a confirmation of the minimum observations at St. Theodule. It is found to be universally true that the extremes of cold are registered not on the summits of the mountains but in the valleys where the chilled air collects.

The winter climate was on the whole cold, as the thermometer never rose above 32° from November to April, but the weather was very enjoyable notwithstanding. At the high level of their station the observers found the intensity of the solar heat on a calm day to be so great that they frequently were sitting in the sun in their shirt-sleeves, when the thermometer in the shade was close to zero F. They often noticed the snow melting when the observed temperature was

7° or 8° F., and even on the peak of Mont Cervin itself they more than once saw traces of a thaw.

As a compensation for the unlooked-for mildness of the winter climate, the summer at the station was extraordinarily cold. The mean temperatures of the three summer months was 32°·3, and that of July, only 33°·5. These are the lowest average summer temperatures that have ever been reported; for the mean of Dr. Kane's stations in Smith Sound was 35°·4 for the summer, and 39°·9 for July. It is well known that at Yakutsk and other stations in Siberia, as well as in North America, where the winter temperature is excessively low, the heat of the summer is comparatively high, approaching and even surpassing that observed in these islands. The result is that a rapid and vigorous, though short-lived, vegetation is produced.

It is hopeless to look for anything of this nature on the Pass of St. Theodule, where frost occurs every night. The perpetual sunshine of an Arctic summer effectually prevents any damage to the growing plants from this cause.

The annual march of temperature at high stations is remarkable. Comparing the observations now under discussion with those from other stations at somewhat lower levels, Dr. Hann finds that February is the coldest month, sometimes even March, while December is extraordinarily mild. In this month it is found that the temperature increases with the elevation owing to the accumulation of cold air in the hollows.

This fact shows the great difficulty of determining accurately the decrease of temperature with height, in any district, the local conditions which influence the result being so very various. However, the Swiss observations throw some light upon it, and Dr. Hann has submitted to the Academy at Vienna a paper on the subject, in which he has calculated provisionally a table to show the rate of this decrease. From this paper we learn that the level of the isothermal contour of 32° varies from 1100 feet in January to upwards of 11,000 in July. If we look for an annual temperature of 0° F., which is about that of Rensselaer Harbour, we find it to lie about 2000 feet over the top of Mont Blanc, while the lowest July temperature at sea level, that of Northumberland Sound, is met with at the level of 10,000 feet in the Alps.

Comparatively little is said about the other meteorological elements. The barometer is dismissed with a few words; but as regards the distribution of moisture the author goes into more length. In winter the air on the mountain tops is dry and clear; in summer it is much more cloudy. The action of the "courant ascendant" is analogous to the foregoing, for the mornings are much less commonly cloudy than the afternoons. As to the actual amount of precipitation at the upper stations, as compared with the lower, there is not much to say. The data for rain and snow are

very uncertain, but on the whole much less fell on the Pass of St. Theodule than might have been expected. The heaviest fall of snow recorded was only 2 feet deep, while in many of the Alpine valleys a depth of 6 or 7 feet is not uncommonly known to fall in the space of twenty-four hours.

The same journal contains a paper by Dr. Dellman, "On the Electricity of Clouds," being one of a series of papers on atmospherical electricity. Our space will only allow us to give some of the most important conclusions. They are as follows:—

All clouds are electrified, and oppositely so in different parts of the cloud.

As far as the observations at Kreuznach go, they prove that all clouds have a negative centre surrounded by positive bands or zones.

The density of the electricity diminishes towards the circumference, but the maximum density is not at the centre.

A cloud can only give rain by the occurrence of an electrical discharge.

With reference to meteorology in Russia, a report has been drawn up by a Committee of the Academy of St. Petersburg on the organization of the system. The most important suggestion which it contains is, that the empire should be divided into separate districts, with a central observatory furnished with self-recording instruments in each. Three of these establishments are now in existence. St. Petersburg; Helsingfors, for Finland; and Tiflis, for the Caucasus. Taschkend is designed as the central station for Turkestan. To these thirteen others are to be added. These institutions are to be quite independent of each other, each being surrounded by its own auxiliary stations, and publishing its own results.

Professor Mohn, of Christiania, has brought out a paper "On Sea-temperatures between Iceland, Scotland, and Norway," based in part on the observations of the Scottish Meteorological Society, and illustrated by charts for the four seasons and for the year. The isothermal curves, at all seasons except the summer, exhibit very sharp bends pointing north-eastwards. Professor Mohn calls the line joining the summits of these curves the thermal axis of the district, inasmuch as on either side of it the temperature decreases. This thermal axis lies parallel to the coast of Norway, at a distance of about 120 miles, excepting in the summer months, when the warmest water is found in the Cattegat, and the thermal axis is only traceable along a line running from the North Cape towards Spitzbergen. This thermal axis indicates the course of the Gulf Stream in these waters, which is rapidly cooled in its progress northwards, on the one hand by the ice in the neighbourhood of Iceland, and on the other by the cold mainland of Norway.

The last number of the 'Journal of the Scottish Meteorological Society' contains a very suggestive paper by Dr. R. Angus Smith

"On Chemical Climatology," or, in other words, on the impurities of atmospherical air. In addition to the ordinary analysis of the gaseous constituents of the atmosphere, Dr. Smith proposes to collect and determine the foreign matter suspended in it. In dry weather, or in covered places such as hospital wards, he shakes some water in a large bottle, containing about a gallon of air, and renews the air as often as necessary. In wet weather he collects rain. The preliminary results are very interesting from a sanitary point of view, but their general bearing is more chemical than meteorological. The author hopes "to be able to tell plainly and authoritatively if a place is close or otherwise; and to say that the rain or the air when washed must not show more than a given amount so as to be fit for respiration. In this way it may be possible authoritatively to fix a limit to the density of population, and the extent to which manufactures may be carried on within a given area." The large amount of solid matter in specimens of rain collected in Glasgow leads Dr. Smith to connect the fact with the great mortality of that town. We are glad to see that a more extensive investigation of the subject is being undertaken, and that rain is being collected at many different stations to be subsequently analyzed by Dr. Smith.

Mr. Buchan gives a preliminary paper "On the Rainfall of the South of Scotland," which is chiefly of local interest, as the rain-gauges are very unevenly distributed over the country. The driest district is the lower part of Teviotdale, where Jedburgh reports 21·99 inches; while the greatest fall is on Ettrick Pen, at a height of 2268 feet, where 71·73 inches were collected. However, the observations on hill-sides show most clearly that no law of increment with height can be assigned—the conditions of rainfall are dependent to so great an extent on the lie of the hills. The fall in the South of Scotland is far less than that in the West Highlands, owing to the fact that Ireland drains the south-west winds of much of their moisture.

The last few numbers of the 'Proceedings of the British Meteorological Society' do not contain many papers of interest. The forty-eighth number is entirely taken up with a paper by Mr. Glaisher "On the Daily Rainfall at Greenwich for the last Fifty-five Years." Although the period is so long, the numbers vary very much from day to day, and the irregularities are not eliminated even by grouping the results for periods of 5, 10, 15, 30, 60, 90, and 120 days. The only practical conclusion arrived at is, that all the periods of least rainfall occur during the first three months, and the heaviest between the months of June and December. The graphical representation of the results gives a very irregular curve. The absolute minimum of daily fall occurs about the end of March, between the eightieth and ninetieth day of the year, and the absolute maximum is noticed in the last half of October, between the 290th and 300th days.

9. MINERALOGY.

To determine with accuracy the true nature of those colouring matters which, although present in extremely minute proportions, nevertheless impart to many of our gems much of their value and their beauty, is a task which has often sorely taxed the resources of the mineralogical chemist. It is still an open question, for example, whether the green tint of the emerald is due to the chromium which the mineral contains, as originally suggested by Vauquelin, or whether it is referable to the presence of certain organic constituents detected in the emerald by M. Lewy. Towards a solution of this question a contribution has recently been published by M. J. Boussingault,* who has had at his disposal more than a couple of pounds of the amorphous emerald from the celebrated mines of Muzo, near Santa-Fé-de-Bogotà, in New Granada. In the carbonaceous schist two kinds of emerald are found—known respectively as *canutillos* and *morallones*—the former being crystallized, transparent, and of great value, while the latter are uncrystallized, less translucent, much fissured, and comparatively valueless: it was, of course, a kilo of the latter that found its way to Boussingault's laboratory. Whilst Lewy has asserted that the emerald becomes opaque and colourless by calcination, Boussingault finds that nothing of the kind takes place with the morallon: the green colour is preserved at a bright red heat, but the mineral suffers a loss of nearly 2 per cent., consisting partly of water and partly of carbon. The water is regarded as existing in a state of chemical combination, since it is not expelled below a red heat, while the carbon is probably derived from the admixture of small particles of the schist in which the mineral occurs, and from which not even the finest crystals are altogether free. On the whole, Boussingault agrees with Wöhler, G. Rose, and Vauquelin, in attributing the colour of the emerald to the presence of oxide of chromium.

It is now several years since Tschermak first enunciated his celebrated theory on the constitution of the felspars, in which he showed that the several species may be regarded as isomorphous mixtures of the two extreme types—albite and anorthite. Some difficulty has lately arisen through Vom Rath's analysis of a Norwegian felspar, regarded as Labradorite, whose composition did not fit in with the theory. Tschermak thereupon called the analysis in question, and asserted that no labradorite could exist free from soda. This proposition has called forth some ingenious observations on isomorphism by Dr. Kenngott.†

* "Analyse de l'Émeraude Morallon des Mines de Muso, Nouvelle-Grenade."—'Annales de Chimie et de Physique,' 1870, p. 328.

† "Ueber den Isomorphismus verschieden zusammengesetzter Körper."—'Journ. f. prakt. Chemie,' 1870, p. 77.

Kenngott assumes that two minerals are strictly isomorphous if the ratio between the number of atoms of metal and of oxygen is the same in the two compounds. Now, albite and anorthite may both be reduced to the general formula: $4\,RO.6\,RO_2$ where the ratio of $R:O = 10:16$. For our author takes the liberty of writing the formula of albite in this fashion: $(Na_2O, Al_2O_3)\,(6\,SiO_2)$; and that of anorthite in this wise: $2\,(CaO.AlO)\,(2\,SiO_2.AlO_2)$. Extending this mode of formulating the silicates, he shows the possibility of the existence of a compound containing $CaO.SiO_2 + Al_2O_3.2\,SiO_2$, for such an expression may be thrown into the form $(CaO.AlO)\,(3\,SiO_2.AlO_2)$, which is now referable to the general type $2\,RO.4\,SiO_2$. Such a compound would be, as Tschermak observes, a labradorite free from soda, but we see at once that it is not isomorphous with albite. We forbear to follow Kenngott's interesting suggestions farther, as they lead across the border-land of chemistry.

In the third number of the new Italian Geological Journal—a journal which we welcome as a fair sign of scientific progress in Italy—Professor Bechi publishes some analyses of minerals from Sig. Foresi's collection.* His examination of some fine limped crystals of beryl from the isle of Elba, show that they are remarkable for containing cæsium, and for holding more alumina and less glucina than other beryls. Traces of lithium were also detected by the spectroscope. A black tourmaline from the granite of the isle of Giglio—an islet rising from the waters of the Tuscan Sea—has also been analysed; and for the sake of economizing space we place the composition of the two minerals side by side:—

Beryl.		Tourmaline.			
Silica	70·00	Silica	36·71	.. Magnesia	0·49
Alumina	26·33	Alumina ..	31·57	.. Soda ..	2·83
Glucina	3·31	Ferric oxide	8·51	.. Potash ..	0·70
Cæsium	0·88	Ferrous oxide	9·39	.. Boric acid	5·56
Oxide of iron	0·42	Lime	0·64	.. Fluorine	1·85

Two substances physically distinct, but occurring together near Brevig in Norway, have hitherto been confounded under the general name of *Esmarkite*. One of these is a true Praseolite, but the other is an extremely rare mineral, which has received Des Cloiseaux's attention during his visit to Norway.† This acute crystallographer has carefully examined authentic specimens of the true Esmarkite, and pronounces it to be merely a laminar variety of the felspar—anorthite.

Several new species recently described demand a cursory notice. *Glaucopyrite* is Professor Sandberger's name for a new mineral, obtained from Guadalcanal in Spain, and consisting of an arsenio-sulphide of iron, in which part of the iron is replaced by cobalt and

* "Analisi chimiche di alcuni minerali delle isole del mare toscano."—'Bollettino del R. Comitato geologico d'Italia,' 1870, p. 82.

† 'Ann. d. Chim. et de Phys.,' 1870, p. 176.

copper, while part of the arsenic gives place to antimony.* Herr Boricky describes, under the name of *Zepharovichite*, a new species allied to Wavellite occurring in the sandstone of Trenic in Bohemia.† Tschermak proposes the name of *Simonyite* for a salt lately found at Hallstadt, closely related to Blœdite, from which it differs, however, in being stable when exposed to the air.‡ Finally, Dr. Schrauf applies the name *Simlaite* to a mineral from Simla in India, similar to meerschaum, but containing alumina, and belonging to the group of halloysites.§

Two Cornish minerals have lately been analyzed by Professor Church—the one a variety of kaolin, akin to lithomarge, and termed *Restormelite;* the other is the beautiful green mineral known as *chalcophyllite*, or copper-mica.‖ The formula of restormelite may be written $Al_2O_3 . 2\ SiO_2 + 2\ aq.$; while the composition of the chalcophyllite may be thus expressed: $8\ CuO . Al_2O_3 . As_2O_5 + 24\ aq.$

Attention is directed by Mr. S. G. Perceval¶ to the occurrence of topazes in the granite of Lundy Island, somewhat similar to the well-known crystals from the granite of the Mourne mountains. The writer of this Chronicle has for several years past been familiar with specimens of both topaz and beryl from Lundy.

Professor How follows up his 'Contributions to the Mineralogy of Nova Scotia' by further notices of the two species—natroborocalcite and silicoborocalcite, now better known under Dana's names of *Ulexite* and *Howlite*.** Both minerals have been found good substitutes for borax in welding.

We learn from the 'Levant Herald' that a large meteorite fell at Mourzouk, in Fezzan, on or about the 25th December, 1869. The fall occasioned considerable consternation to a group of Arabs who were standing near, and they immediately discharged their muskets on the unwelcome stranger.††

It seems likely that the Australian mineral lately introduced under the name of Wollongongite will in future be known by some more appropriate designation. The Rev. W. B. Clarke has pointed out that some little error has arisen in assigning to this species a local habitation and a name. In fact, the so-called Wollongongite occurs not in Illawarra, but at a place called Petrolia, formerly known as Reedy Creek, where it was recognized by Count Strzelecki as far back as 1839. Under these circumstances the name ceases to be appropriate, so that "there can be no question, I think," says Mr. Clarke, "that Wollongongite is a misnomer, and that Professor Silliman will change it."

A good deal of common sense characterizes the little minera-

* 'Jahrbuch f. Mineralogie,' 1870, p. 196. † Ibid., p. 229.
‡ 'Sitzber. d. Kais. Acad. d. Wiss., 1869. No. XXV.
§ 'Corr. Blatt. d. z. Mineralog.' V. in Regeusburg, 1870. p. 64.
‖ 'Chemical News,' May 13, 1870, p. 223. ¶ 'Geolog. Mag.,' 1870, p. 192.
** 'Phil. Mag.,' April, 1870, p. 275. †† 'Nature,' vol. i., p. 538.

logical guide which Dr. A. M. Thomson has published in Sydney,* for the assistance of explorers seeking to develop the mineral resources of the colony. Plain directions are given for easily recognizing the more important species—a task at all times extremely embarrassing to the unassisted beginner.

10. MINING AND METALLURGY.

Mining.

The newly drafted Bill amalgamating the Mines Regulation Bill and the Metalliferous Mines Bill has been printed. We cannot but think that this amalgamation will be found to be unfortunate. Nearly all the conditions of a coal mine and a copper or tin mine are so different, that it is quite impossible to apply the same legislation to them with any hope of advantage. This is shown on the face of the Bill itself. It now comprehends *three sets* of General Rules: one applicable to all mines; the second, to coal mines only; and the third, to mines other than coal mines. The redrafted Bill is supposed to embody the suggestions of the representatives of all the interests affected—it is therefore probably now in that form which will become law. In the last Quarterly Journal we sufficiently entered upon the principles of the Mines Regulation Bill, and therefore we need not occupy valuable space by enlarging upon its clauses.

Tin mining has, once again, resumed its condition of high prosperity in our western counties; the prices of tin ore (black tin), which have varied during the past quarter from 75*l.* to 85*l.* the ton, being such as to leave a large profit to the miner. The result of this is that numerous new tin mines are being opened, and the miners have full employment and are getting good wages.

Copper mining is not in the same favourable condition. The Clifford Amalgamated Mines, which employed a short time since upwards of a thousand persons, are about to be abandoned, after a long and profitable career. These mines—which comprehend the United Mines, the Gwennap Consolidated Mines and Wheal Clifford—were the most extensive copper mines in this country. The levels were upwards of sixty miles in length, and from six to seven miles of shafts had been sunk upon the lodes. This mine was remarkable for the very high temperature of its lower levels. The miners in some of the ends of the levels worked in temperatures varying from 110° F. to 115° F., the water rising in those levels being at the temperature of 120 F. This hot spring was remark-

* 'Guide to Mineral Explorers in distinguishing Minerals, Ores, and Gems.' By Alexander M. Thomson, D.Sc. Sydney, 1869.

able for the great quantity of lithium which it held in solution. All the lower parts of the mine are now filled with water; a little tin is being obtained from the shallow levels; the machinery is being removed; and soon this scene of activity will become a silent ruin.

At Wheal Owles, in the mining district of St. Just, there have lately been discovered some valuable samples of the oxide of uranium, which have been sent into the market and realized high prices.

The Gold-fields of Nova Scotia.—The declared returns of gold for the whole province to the end of the year 1869 are as follows:—

Year.	Yield of Gold.	Number of Miners daily employed.	Quartz crushed.	Average yield per ton.	Annual earnings per man.
	oz. dwt. gr.	No.	cwts.	oz. dwt. gr.	$ c.
1862 ..	7,275 0 0	500	134,800	1 3 2	291 00
1863 ..	14,001 14 17	877	340,035	0 18 10	319 30
1864 ..	20,022 18 13	810	428,700	1 0 20	494 36
1865 ..	25,454 4 8	683	500,025	1 3 6	745 76
1866 ..	25,204 13 2	679	635,387	0 17 13	742 56
1867 ..	27,314 11 11	702	666,429	0 19 10	778 66
1868 ..	20,541 6 10	774	678,817	0 14 6	530 84
1869 ..	17,868 10 19	676	708,486	0 11 5	528 64
Total ..	157,682 9 8	713	4,092,679	0 15 10	553 90

The gross yield of gold in Nova Scotia during the past ten years has been 180,000 oz., representing, in round numbers, a value of 720,000*l.* sterling.

The produce of gold in Nova Scotia for the year ending 31st December, 1869, in all the gold-producing districts, is shown in the following Table:—

District.	Total yield of Gold.	Daily average of miners employed.	Quartz crushed.	Average yield per ton.	Value of average yield of Gold per man employed at $18·5 per oz.
	oz. dwt. gr.	No.	tons. cwt.	oz. dwt. gr.	£ s. d.
Stormont ..	227 0 13	19	784 0	0 5 19	47 15 11
Wine Harbour	719 8 19	65	2,726 12	0 5 6	44 5 6
Sherbrooke ..	5,546 11 16	134	11,500 0	0 9 15	165 11 6
Tangier	1,192 3 10	51	1,332 2	0 17 21	93 5 6
Montague ..	805 13 14	29	572 7	1 8 3	111 2 7
Waverley ..	1,591 14 10	54	3,915 15	0 8 3	117 18 1
Oldham	1,394 16 0	56	1,735 2	0 16 1	99 12 7
Renfrew	3,097 15 7	112	7,258 9	0 8 12	110 12 9
Uniacke	1,867 3 12	71	3,171 13	0 11 18	105 3 10
Lawrencetown .	30 0 20	20	223 0	0 2 16	6 1 8
Musquodoboit .	1,001 0 23	36	1,582 17	0 12 17	111 4 7
Unproclaimed districts ..	394 11 19	29	622 9	0 6 23	54 8 7
	17,868 0 19	676	35,424 6	0 10 2	105 14 7

The produce of gold for the month of February, 1870, being according to the Mineral Inspector's Report, as follows:—

District.	Gold yield.	Quartz crushed (Colonial weight).
	oz. dwt. gr.	tons.
Sherbrooke	309 0 0	694·03
Tangier	135 7 20	88·00
Oldham	104 7 14	200·07
Waverley	78 7 0	141·00
Renfrew	71 2 0	223·10
Musquodoboit	52 5 21	73·10
Uniacke	47 2 4	105·00
Wine Harbour	28 7 12	100·10
Isaac's Harbour	2 11 15	3·10

Mr. R. Brough Smith reports that the total quantity of gold raised in Victoria in 1869 was 1,544,757½ ounces, and of this there were exported 1,340,838½ ounces. The total imports into England of Australasian gold in 1869 were of the value of 7,892,757*l.* Since 1858 the imports have been as follows:—

	£.		£.
1858	9,064,763	1864	2,656,971
1859	8,624,566	1865	5,051,170
1860	6,719,000	1866	6,836,674
1861	6,331,225	1867	5,801,207
1862	6,704,753	1868	6,989,594
1863	5,995,368		

The increased returns of the last three years were due to the opening of new gold-fields in Queensland, South Australia, and New Zealand.

Metallurgy.

Mr. Spence, of Newton Heath, Manchester, has patented a new process of separating copper from ores. He takes the solution of chloride of copper as now obtained in extracting copper from ores (by the wet process) which contains iron in variable proportions, and generally contains free hydrochloric acid. This solution he places in large open vats, and in another vessel of cast iron, fitted with a revolving stirrer, he places a considerable quantity of the vat waste of the alkali manufacture, or the spent lime from the gas purifiers, and to this is added a solution of sulphate of ammonia, or chloride of ammonium. The vessel or still being closed, a jet of steam of from 20 to 30 lbs. pressure is blown into the mixture. Sulphide of ammonium distils over, and is conveyed by a pipe into the vat containing the metallic solution of copper and iron, by which sulphide of copper is precipitated, and the ammonia combines with the

liberated hydrochloric acid. The process is continued until all the copper is thrown down, which point is at once observed by sulphuretted hydrogen being evolved, when the process is stopped; for if continued, the ammonia would now neutralize the free acid, and the iron would then be precipitated. The sulphide of copper thus obtained is very nearly pure; it is washed and dried, and smelted into copper by any of the usual methods employed.

A new process of calcining tin and other ores has been adopted by Messrs. Oxland, F.C.S., and John Hocking. The ores are introduced into a revolving iron cylinder, 4 feet in diameter and 30 feet long, lined with fire bricks, and supported at an inclination of about ¾ inch per foot on three pairs of rollers, on which it is kept constantly revolving at a slow rate. The fire passes from the fire-place over a chamber into and through the tube. The ore having been first dried on iron plates in suitable flues, at the back of the calciner, is admitted in a steady stream into the higher end of the cylinder, and the slow revolving motion imparted to it causes the advance of the ore by its own gravitation, and it is discharged in a continuous stream into a chamber between the fire-place and the front of the tube. Great economy of fuel is said to be effected by this furnace. The heat from the fuel has to traverse more than double the distance over which it passes in Brunton's calciner before it escapes into the flues, and the tube presents nearly double the amount of heating surface. None of the working parts are exposed to the action of the fire. In working it is found to be economical both as regards fuel and labour.

Several patents have been taken out of late relating to the manufacture of iron and steel. Mr. Cowper, of Westminster, patents improvements in treating cast iron for the production of wrought iron and steel therefrom. By this process the purification of the cast iron is accomplished by a jet of superheated steam applied to a stream of the liquid iron as it flows from the blast furnace, so as to divide it up into small particles, and act upon them; the iron is received into a hot box, and transferred to a calcining furnace, in which it is kept hot whilst still exposed to an atmosphere of hot steam; such purified iron is mixed either hot or cold with liquid cast iron, and afterwards used as cast iron, or made into steel or wrought iron.

In the manufacture of steel Mr. Julius Baur, of New York, patents a process of alloying or combining metallic chromium with metallic iron, so that chromium in a metallic state shall be present in the finished product, which is said to impart valuable properties to it. This process is distinguishable from that secured by Mr. Robert Mushett for mixing oxide of chromium in the manufacture of steel.

Letters patent have also been granted to Mr. J. M. Stanley, of Sheffield, for improved modes of utilizing the heat given off during

the decarbonizing or converting process, the object of which is to economize the consumption of fuel, and reduce the cost of the metals.

There is also an invention whereby very superior iron and steel are said to be obtained by smelting titanic iron ore, Ilmenite, in a blast furnace, without the addition of any other metalliferous body; the alloy of iron thus obtained possesses a large percentage of carbon. Various methods are adopted to carry out this process. The inventor is Mr. T. S. Webb, of the Norton Iron Works.

11. PHYSICS.

Light.—Spectrum analysis has been applied by Vogelsang and Geissler to the difficult question of determining the chemical nature of the fluid found enclosed, in minute quantity, in the cavities of certain quartz-crystals. Fragments of quartz were placed in a small retort, which was connected with an air-pump and exhausted; then, by the application of heat, the quartz decrepitated, and the evolved vapour was examined in a Geissler-tube. The presence of carbonic acid was thus abundantly proved, and this was confirmed by the turbidity which it produced in lime-water.

A great improvement in the spectroscope has been made by Mr. Browning, who calls his instrument the automatic spectroscope. It is furnished with a battery of six equilateral prisms of dense flint glass; all the prisms are joined together like a chain by their respective corners, the bases being in this manner linked together. This chain of prisms is then bent round so as to form a circle with the apices outwards; the centre of the base of each prism is attached to a radial rod. All these rods pass through a common centre. The prism nearest the collimator, *i. e.* the first prism of the train, is a fixture. The movement of the other prisms is then in the proportion of 1, 2, 3, 4, and 5, the last or 6th prism moving five times the amount of the second. All these motions are communicated by the revolution of the micrometer screw, which is used for measuring the position of the lines in the spectrum; and the amount of motion of each, and of the telescope, is so arranged that the prisms are automatically adjusted to the minimum angle of deviation for the ray under examination. It is easy to test the efficiency of the instrument in this respect. On taking the lens out of the eye-piece of the telescope, the whole field of view is found to be filled with the light of the colour of that portion of the spectrum which the observer wishes to examine; while in a spectroscope of the usual construction, at the extreme ends of the spectrum, just where the light is most required, only a lens-shaped line of light would be

found in the field of view. As a consequence of this peculiarity, the violet and deep-red ends of the spectrum are greatly elongated, or rather, much more of them can be seen than in an ordinary spectroscope, and the H lines, which are generally seen only with difficulty, come out in a marked manner.

Drs. Roscoe and Thorpe have recently communicated to the Royal Society the results of a series of determinations of the chemical intensity of total daylight, made in the autumn of 1867, on the flat plateau of the river Tagus, about 8½ miles south-east of Lisbon, under a cloudless sky, with the object of ascertaining the relation existing between the solar altitude and the chemical intensity of the light. The experiments were made as follows:—1. The chemical action of total daylight was observed in the ordinary manner; 2. The chemical action of the diffused daylight was then observed, by throwing on to the exposed paper the shadow of a small, blackened, brass ball, placed at such a distance that its apparent diameter, seen from the position of the paper, was slightly larger than that of the sun's disk; 3. Observation No. 1 repeated; 4. Observation No. 2 repeated. Next, the means of observations 1 to 4 were taken. The sun's altitude was determined by a sextant and artificial horizon. One of the sets of 134 observations was made as nearly as possible every hour. It has been already pointed out, and proved by experiments made at Kew, that the mean chemical intensity of total daylight, for the hours equidistant from noon, is constant. The results of the present series of experiments prove that this conclusion holds good generally. One of the chief results arrived at is that, although the chemical intensity for the same altitude, at different places and at different times of the year, varies according to the varying transparency of the atmosphere, yet the relation, at the same place, between altitude and intensity, is always represented by a straight line.

A new and very ingenious graduating diaphragm for the microscope has been contrived by Mr. J. Zentmayer. This exceedingly ingenious arrangement is shown in the accompanying cuts, which are taken from photographs; Fig. 1 showing the apparatus with

Fig. 1.

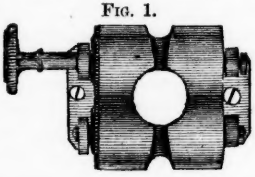
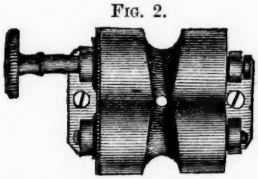


Fig. 2.



its largest, and Fig. 2 with its smallest opening. To obtain a circular diaphragm which, like the eye, should expand and contract

gradually by a continuous change, and yet be made of rigid and unchangeable material, might seem at first sight to be an impossibility; but, after all, when the result is accomplished, as in this apparatus, we are surprised as much by the simplicity as by the ingenuity of the means employed. The woodcuts almost explain the apparatus of themselves; but we may say, in addition, that it consists of two cylinders or rollers with parallel axes and surfaces in contact, having similar conical grooves on their surfaces, and fine teeth cut at one end of each, which, gearing together, cause them to rotate in unison. There is, theoretically, an objection to a diaphragm of this construction, from the fact that its opening will not always be in the same plane—that is, the smallest cross-section of the space between the rollers will not always be equidistant from a plane at right angles to the line of sight and passing through the axes of the rollers. With the larger opening, this cross-section will be nearest to, and with the smaller, farther from, such a plane. In practice, however, this difference is so small as to be entirely unimportant, and may even, in some cases, be turned to advantage.

Experiments have been made at Toulon by M. F. Silvas to try to attach to life-buoys another floating body provided with phosphide of calcium, which, on becoming wet, gives off spontaneously combustible phosphuretted hydrogen, thus emitting light to guide the man, who might have fallen overboard and be in search of the life-buoy.

HEAT.—Dr. Guy has arranged in series the different poisonous substances according to their melting and sublimation temperatures. The arrangement is as follows:—(1) Sublimates formed without any previous change of state of aggregation, and giving white vapours; under this head are brought bichloride of mercury, calomel, arsenious acid, and cantharidine. (2) Sublimates after previous fusion, and without leaving any residue—*viz.* oxalic acid. (3) Sublimates after previous fusion, leaving a carbonaceous residue—morphine and strychnine. (4) Fusion, change of colour, sublimation and deposition of carbonaceous residue, aconitine, atropine, delphine, veratrine, brucine, digitaline, picrotoxine, solanine. (5) Decrepitation; slow and partial sublimation; tartar emetic.

Professor Morren has instituted some experiments on the combustibility of diamonds, and the effect of a high temperature on these gems. The author, in a letter, first relates the following facts as having given rise to his experiments. A jeweller at Marseilles was requested to enamel afresh the gold bearings of two large diamonds of great value, used as shirt buttons. Instead of taking off the diamonds, always a delicate operation, the jeweller, who had frequently executed such work previously, decided to enamel the gold while the diamonds were left on their bearings. Not having

charcoal at hand, the jeweller took coal for heating the muffle for enamelling, an operation which succeeded most perfectly; but on taking the buttons from the muffle, the jewels had become perfectly black, and no amount of rubbing or friction restored them to their pristine state. The jeweller was therefore obliged to dismount the jewels, which looked like plumbago, and to send them to Paris, when by the first touch of the lapidary's wheel they became restored to their former beauty; while, curiously enough, their weight had not changed. Professor Morren who, through the kindness of MM. Laurin, jewellers at Marseilles, was enabled to experiment with several diamonds, placed them on a small platinum boat in a platinum tube, and tried the effect of a high temperature simultaneously with different gases. Heated in coal-gas the gems become blackish, increase in weight, and are found to be coated with a strongly-adhesive layer of carbon, such as is deposited in gas retorts; in pure hydrogen, the gems may be heated almost to the melting-point of platinum without undergoing any change; heated in carbonic acid gas, the gems become dull and lose a little weight. The carbonic acid gas was found to be dissociated into carbonic oxide and carbonic acid; this, the author found, was caused by the platinum and not by the diamond. When the diamond is placed in oxygen gas and ignited, it continues to burn, but remains white, appearing as a piece of unpolished glass; the stone does not blacken, nor swell up, and, if it is free from flaws or cracks, does not split asunder.

Dr. Janssen, who, it will be remembered, went to India for the purpose of observing the total solar eclipse, has communicated some observations on the artificial production of ice in India. In many parts of the Indian continent, the natives dig shallow pits in localities which are freely open to the sky and distant from trees. The pits are lined with straw, and upon the straw are placed dishes (made of a very porous earthenware) filled with water. During the calm and clear nights prevailing in the period from November to the end of February the water placed in the dishes freezes, yielding a solid cake of ice, while the temperature of the air is $+ 10^{\circ}$. Dr. Janssen has investigated this curious subject experimentally, and has found that the freezing is principally due to the radiation during the night; but the evaporation of the water, aided by the porosity of the earthenware employed, is at the same time not to be overlooked.

In order to exhibit the effect of the expansion of water when freezing, F. Rüdorff fills with distilled and previously well-boiled and cooled water a cast-iron cylinder, having the following dimensions:—Height, 160 millimètres; diameter (external), 50 millimètres; thickness of solid iron, 15 millimètres. After having been filled with water this apparatus is closed by means of a plug screwed into the neck, and the cylinder is next placed in a mixture of three parts

of snow or pounded ice, and one part of common salt; after about forty minutes the cylinder bursts with a loud report. It is essential for the success of this experiment that the plug fits very perfectly, and that the cylinder, after having been filled with water, be placed for some time in ice. The wooden pail which contains the freezing mixture should be roomy, and be covered with a stout towel to prevent the spirting about of the contents at the time of the bursting.

Some experiments on the freezing of wine have been tried by A. Rousselle. The reason why freezing improves wines, under certain conditions, is, according to this author, because by partial freezing the proportion of all the fixed substances in the liquid wine is increased; and these are, moreover, thereby rendered more fit for causing the combination of the acids with the alcohol, so as to form those ethers to which wine owes its peculiarly distinct flavour, aroma, and strength.

Dr. Hann has tried to solve by observation the problem of the decrease of the temperature of the air in relation to the elevation above sea-level, by comparing the average of temperature as observed at certain groups of stations situated under the same mean latitude and longitude, and by taking into account local influences. Seven of these groups are situated in the western portion of the Alps, at from 230 to 3330 mètres above sea-level; four in the northern part of Switzerland, at from 500 to 1780 mètres above sea-level; three in the Rauhe Alps (Wurtemburg), at from 310 to 810 mètres above sea-level; four in the Erzgebirge (Central Germany), at from 180 to 850 mètres above sea-level; and four in the Harz (province of Hanover and Brunswick), at from 70 to 1140 mètres above sea-level. The results obtained have proved that, in the instances mentioned, the decrease of the temperature of the atmosphere near the ground is really proportionate to the height of the locality above sea-level. When the results of all the observations are duly considered, there is discovered a strongly marked annual periodicity, and a very uniform decrease of temperature from below to above, the average relation of the temperature reigning in December being, to that of June, as 1 to 2.

Dr. Von Wartha has obtained solid disulphide of carbon by the rapid evaporation of this liquid itself, in the same way as solid carbonic acid is formed. The solid sulphide melts at 9° F., and has the appearance of small cauliflowers.

Some time ago M. Lamy proposed a pyrometer based upon the dissociation of carbonate of lime. He now proposes to apply ammoniacal chloride of calcium, which gives off ammonia at low temperatures. The instrument is to be connected with a manometer, which will record the temperature. The contrivance is to be especially adapted to record the temperature at different depths under the

surface of the soil. In reference to this, M. E. Becquerel and others have very properly observed that better and far more accurate means for accomplishing this purpose exist already, and are daily employed with success.

A valuable substance for crucibles and fire-bricks has recently been discovered. There occurs, in the Département des Ardennes, France, a variety of hydrated silica known by the name of gaize, and geologically situated below the cretaceous deposit; the thickness of this layer is 30 mètres, and it extends over a distance of 24·85 English miles. The sp. gr. of this substance is 1·48 in crude state, and after ignition 1·44. This stone is used as a building stone; it is, at first, quite soft, so that it can be cut with a knife. The material resists a very high temperature without fusion or cracking, or, also, of perceptible contraction, either cubical or linear, and it has consequently been recommended for the manufacture of crucibles (on the lathe), for fire-bricks, and for furnaces.

Electricity.—A cause of error in electroscopic experiments has been pointed out by Sir Charles Wheatstone, F.R.S. In the course of some experiments on electrical conduction and induction the author was frequently delayed by what at first appeared to be very puzzling results. Occasionally he found that he could not discharge the electrometer with the finger (or only to a certain degree), and that it was necessary, before commencing another experiment, to be in communication with a gas-pipe which entered the room. How he became charged could not at that time be explained; observation and experiment, however, soon led Sir Charles to the true solution. He was sitting at a table not far from the fire-place, with the electrometer (one of Peltier's construction) before him, and was engaged in experimenting with discs of various substances. To ensure that the one in hand (which was of tortoiseshell) should be perfectly dry, it was held for a minute before the fire. Returning, and placing it on the plate of the electrometer, it had apparently acquired a strong charge, deflecting the index of the electrometer beyond 90°, and it was then observed that the same thing took place with every disc thus presented to the fire, whether of metal or any other substance. The first impression was that the disc had been rendered electrical by heat; but, on placing it in contact with a vessel of boiling water, or heating it by a gas-lamp, no such effect was produced. The next conjecture was that the phenomenon might arise from a difference in the electrical state of the air in the room, and that at the top of the chimney. That this conjecture, however, was not tenable was soon evident, because the same deviation of the needle of the electrometer was produced by bringing the disc near any part of the wall of the room. This seemed to indicate that different parts of the room were in different electrical states; but this, again, was dis-

proved by finding that, when the positions of the electrometer and the place where the disc was supposed to be charged were interchanged, the charge of the electrometer was still always negative. The last resource was to assume that the author himself had become charged by walking across the carpeted room, though the effect was produced even by the most careful treading. This ultimately proved to be the case; for, resuming his seat at the table, and scraping the foot on the rug, Sir Charles was able, at will, to move the index to its greatest extent.

As a substitute for copper for the Daniell Electric Battery, Dr. C. Stölzel proposes to take a piece of well-polished tin plate (sheet tin, not tinned iron), immerse it in a very dilute solution of a copper salt, and put it in connection with a weak galvanic current. After the lapse of from fifteen to eighteen hours a layer of strongly adhering metallic copper will have become firmly deposited upon the tin plate; and the latter, after having been bent into the required shape, is an excellent, cheap, and durable substitute for the copper cylinder in Daniell's battery.

Considering the numerous experiments now being tried on wine, it is to be hoped that the quality of the cheaper kinds of this beverage will shortly show some improvement. Whilst Dr. Rousselle proposes to freeze wine, Dr. Scontettin prefers to electrify it. As a very tangible proof of the gain obtained by the immediate conversion of young wines into drinkable beverages by means of electricity, the author states that, considering that the annual production of wine of France amounts to from 60 to 70 millions of hectolitres (each equal to rather more than 22 gallons), and that at least 10 francs per hectolitre is lost by vaporization during the time of the maturity of the wine while in casks, this represents an amount of from 600 to 700 millions of francs gained by rendering wine fit for immediate consumption by the author's electric process. We may not inaptly apply here, "Si non e vero e bene trovato."

Some useful electrolytic experiments have been tried by P. Burckhard. After describing his arrangement, the author states that oxide of bismuth is not a conductor of electricity unless it be in a state of fusion, but in that case one of the copper electrodes becomes coated with bismuth; while, if platinum electrodes are used, there is formed at one of the electrodes a very fusible alloy of the two metals. Fused borax is not a bad conductor, although the author confirmed the statement made by Dr. Tichanowitsch that pure boric acid does not conduct electricity at all. When borax in a fused state is experimented with, a series of compounds are formed or volatilized; but the main result is its decomposition into soda, oxygen, and boron. Pyrophosphate of soda in a fused state yields, among the products of electrolysis, phosphide of platinum,

XUM

if a platinum electrode be applied; but the decomposition, which is chiefly the result of the electrolysis of this salt, is its splitting up into oxygen, phosphorus, and soda. Carbonate of soda in a fused state is a good conductor of electricity; it is decomposed into carbonic acid and soda, but a small portion of carbon is also formed.

A series of very accurate experiments, made with chemically pure substances, have been tried by M. E. Becquerel, on the electromotive force of divers substances, as for instance, pure carbon, gold, platinum, &c., in the presence of water and other fluids. Among the curious facts elicited is this, that pure gold, obtained from the French Mint, is acted upon by pure water in a manner not hitherto explained, but which gives the author occasion to ask whether possibly gold does not contain another substance which has not been discovered, or whether perhaps the slow action of the water is not the cause of the disaggregation of the gold, thus explaining the fact of its being found in rivers in the state of dust.

In a very lengthy paper on the properties of galvanically-precipitated iron, R. Lenz records a series of experiments, not only made with iron, but also with copper. The results are stated as follows:—Iron and copper, when reduced to the metallic state by electricity, contain gases occluded, among which hydrogen is in largest amount: the bulk of gas thus occluded varies considerably, but iron has been found by the author to occlude as much as 185 times its own bulk. The absorption of the gases is more considerable in the first layers of metal deposited. On being heated, the iron loses gas, even below 100°, the gas evolved at so low a temperature being chiefly hydrogen. Iron which has been galvanically precipitated, and then made red-hot and cooled, becomes oxidized when put into water, that liquid being decomposed and hydrogen given off.

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12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY.

Morphology.

A new Ganoid Fish from Australia.—We have this quarter to record what is certainly the most important zoological acquisition which science has received since the finding of the Archæopteryx of Solenhofen. Mr. Gerard Kreft, the able curator of the Australian Museum of Sydney, who has already by his single exertions shown us what a rich mine of new forms is still waiting to be brought to the hands of science in the Australian continent, has sent over photographs of a fish obtained in the rivers of Eastern Queens-

land, which has at first sight very much the aspect of the African *Protopterus* or South American *Lepidosiren*. The Queensland fish is, however, larger than Lepidosiren, measuring nearly 5 feet in length. A further examination of the photographs sent by Mr. Kreft shows that the fins, which are long worm-like appendages in Lepidosiren, with a very slight border of fin-rays, are here much more developed, being broader and flat, with a large axial lobe and diverging rays, something like those of *Polypterus*. The scales are large and solid-looking—to judge by the picture—and with a wave-like sculpture on the surface, recalling the palæozoic Holoptychius in this respect, as well as in the long-lobed fin. The photographs of the skull display a most formidable array of long, wedge-shaped teeth, with undulating edges, exceedingly like those of the Carboniferous Ceratodus. The teeth are, in their limited number and position, very similar to those of Lepidosiren, but have even a more marked resemblance to Ceratodus than have the latter. Mr. Kreft was so struck with the resemblance to Ceratodus that he has proposed to call this marvellous fish, which he places with amphibians, *Ceratodus Forsteri*, after the gentleman who discovered it. The name *Potamothauma* has, however, been also proposed, since we have no right to relegate it to an extinct genus solely on the ground of agreement in the teeth. It is impossible to exaggerate the importance of this discovery with reference to the problems of the geographical distribution of organisms, and the ancient relations of land and water. On the other hand, this fish has an equal interest from the purely zoological point of view. We believe that specimens are not very difficult to obtain, so that some may soon be expected in this country. How is it that no one has yet studied the development of Lepidosiren? Surely, now that in three-quarters of the globe such a fish has been found, the eggs and fry may be expected to be made known. It is only quite recently that the development of Polypterus—the Ganoid of the Nile—has been studied on the banks of its habitation, and the fact that it commences life with large external gills like those of a young Newt, or of a very young Tadpole, clearly established.

The Graphic Method in Odontology.—The study of teeth, not from the dentist's but from the naturalist's point of view, is of very great importance, since by the power of drawing correct inferences from a few teeth we are able to arrive at most weighty conclusions as to the age of Tertiary and other strata. The study of teeth, particularly of mammalian teeth, has become quite a speciality—a little field of knowledge requiring great care and perception of form for its successful cultivation, and standing apart from other anatomical work. So great is the amount of attention required in this study, and so great the importance attached to it, that the late Dr. Falconer occupied most of his life with the study of the teeth of Elephas, Mastodon, and Rhinoceros; whilst a fellow of the Royal

Society has been raised to that dignity because he had confined his studies to the molar series of Rhinoceros and Hyæna. Anything which will simplify this study and reduce it to the level accessible to ordinary minds must therefore be hailed with pleasure, and the method which Mr. George Busk has devised is exceedingly valuable in that way. Mr. Busk proposes to convert *number* into *form* in the case of teeth, for increase of twentieths of an inch in breadth using extension of a line, just as the mathematician proceeds in drawing a curve representing progressive phenomena. The paper ruled in fine squares of a tenth of an inch or so, which physiologists and others make use of in recording rises of temperature or increase of movement at successive intervals, is employed by Mr. Busk. To obtain the odontogram of any mammal, you mark off as many horizontal lines as there are teeth in the molar series; let each division on the horizontal lines made by the perpendicular represent, say a tenth of an inch; then with compasses measure the breadth of your first molar, mark it with a dot on the first horizontal line in tenths of an inch; then measure the second and mark it on the second line, and so on for all seven—if seven there be. Your dots will now be at various distances from the perpendicular zero line, according to the breadth of each tooth: join the adjacent dots and you have an irregular figure produced of *definite* form and *characteristic of the species*. On the same set of lines you can now measure out the lengths, or antero-posterior dimensions of the same teeth, and produce a figure overlapping your first figure, equally characteristic, the two together giving an exceedingly accurate and trustworthy means of comparing the dental series in allied species. With regard to the teeth of some of the large pachyderms Mr. Busk has proposed certain points of measurement besides those of length and breadth, which we may hope soon to see adopted. It would be an inestimable boon to palæontologists if Mr. Busk would found a system of measurements for all mammalian teeth, and publish at the same time an authoritative series of such measurements with odontograms of all the known recent and fossil mammalia. It at any rate might be done with Rhinoceros and the Carnivora to begin with.

The Zoological Position of Sponges.—It is not three years since in chronicling the discussions to which the glass-rope sponge, *Hyalonema*, gave rise, we had to mention that Ehrenberg the great microscopist—who still is in Berlin outliving his age—holds to his old belief that Sponges are Vegetals. We have now to record that Professor Ernst Haeckel, of Jena, proposes to associate the Sponges with the Corals and Hydromedusæ, bringing them under the group Cœlenterata. Haeckel has attacked in former years that heterogeneous assemblage which we still know as the Protozoa; and he removed from it the Infusoria proper, leaving the Sponges, the Radiolarians, the Amœboids, the Foraminifera, the Gregarines, and

the Monera (a group of simplest forms which he himself discovered) associated with the Flagellata and Diatomaceæ as Protista. Haeckel now proposes—with very great propriety, we think—to remove the Sponges from this company, with which they have no close relation at all, their complex aggregated structure finding no parallel in any of the other groups, and the fact that they are built up of amœboid and ciliate cells in large measure, being absolutely as true for all animals as for Sponges. Two years since in the Canaries, Haeckel was with his pupil, Miklucho-Maclay, and there the latter paid particular attention to the calcareous Sponges, and both he and Haeckel were much struck with the high degree of organization which these forms presented. Haeckel has since studied the calcareous Sponges (which are represented by the genus Grantia on our coasts) in the Adriatic; has found an immense number of new forms, and has watched the development of a great number. He now points out that the central orifice, or "osculum," of such a sponge as *Grantia* is homologous with the mouth of Cœlenterata; that the canals of the Sponge too are homologous with the canal-system of Corals, though they open externally by the temporary pores in the former. He describes a small form, *Prosycum*, which has not canals opening thus, but only the central orifice, and this he considers very near to the common ancestor of the Sponges and Nematophora (Corals, Hydræ, Ctenophora), which he distinguishes as *Protascus*. Haeckel can distinctly demonstrate an endoderm and ectoderm in many Sponges, whilst in some of the Calcispongiæ we have the presence of those radiating septa or "antimera" so characteristic of Corals. The Calcispongiæ make the nearest approach to Nematophora by the distinctness of the "persons" which they present, each osculum, or mouth, and canal-system stands alone, like a separate polyp. In other Sponges there is much fusion and merging of persons into a common individuality—in various ways which Haeckel explains—one of these consisting in the possession of a single osculum by several persons. Professor Haeckel's proposal has already been attacked in England by Mr. Kent, of the British Museum, who thinks that the osculum of a sponge cannot be the homologue of the mouth of a sea-anemone, because the water runs in at the latter but out at the former—really no reason at all as far as homology is concerned. He also thinks Cœlenterata differ from Sponges in having free-will, which Sponges have not, and declares the Sponges to be the head of the Protozoa.

Spermatophores in Fresh-water Annelids.—In the last number of the 'Quarterly Journal of Microscopical Science,' Mr. Ray Lankester announces the discovery of these structures in the genera *Nais*, *Tubifex*, *Limnodrilus*, and *Clitellis*. Peculiar elongate bodies fringed with slowly-moving cilia, and occurring in the seminal receptacles of *Clitellis* and *Limnodrilus*, had been described under

the name *Pachydermon* by M. Claparède as parasites, similar to the well-known *Opalinæ*. Mr. Lankester having detected these bodies in a new species of *Limnodrilus* living in ponds at Hampstead, carefully examined their structure, and found that they were simply closely-fitted masses of spermatozoa, held together by a viscid cement, and with their tails projecting beyond this viscid matter freely, and thus giving the appearance of ciliation. Further, Mr. Lankester had observed exceedingly long coiling bodies in the seminal receptacles of *Nais*, and he had no doubt from their structure that these also were spermatophores. This curious phenomenon of the aggregation of the spermatozoa into definitely-shaped masses after their complete development and separation from their developmental aggregation, has been observed in Molluscs, Insects, and Marine Annelids, but not hitherto in the Oligochœta. It is not easy to conjecture what purpose may be served in the worm's economy by this strange aggregation of the spermatozoa. The appearance presented by the masses is very like that of a densely-ciliated Infusorian, and they move gracefully along the stage of the microscope as though endowed with an individual vitality, instead of being but a spirally-interwoven mass of sexual particles. The same number of the Journal contains an important paper by Professor Cleland "On the Structure of the Grey Matter of the Brain," and one by Dr. Van Beneden "On *Nematobothrium*."

Surface Life of the Ocean.—Lieutenant Ingram Palmer, having a considerable talent for drawing, determined to investigate the various minute forms of life which abound on the ocean surface. He arranged a series of nets for towing behind the vessel to which he was attached; purchased a small microscope, and set to work to examine everything and draw everything which came to hand. The result is, a very large collection of beautifully-executed drawings of minute crustacean larvæ, worms, Pteropodous Molluscs, Echinoderm larvæ, and various adult Amphipods and Isopods of great beauty, few being larger naturally than a pin's head. The amount of work and skill represented by these drawings is something enormous, and yet they will probably prove of no scientific value. They have been exhibited at the Geographical and Linnæan Societies, and are now in a magnificent frame at the Admiralty. The talented and persevering artist who produced them had absolutely no knowledge of what he was drawing, and did not go to work with the critical power of a zoologist, and hence he has drawn much that was well known before, and has often failed to give the details required for zoological purposes, though his drawings are exceedingly clear and accurate. A very little previous education in Natural History—the opportunity for which ought to be given to every officer in Her Majesty's service—would have rendered Lieutenant Palmer's great talents available for science. It is to be hoped that the Admiralty

will now grant him the time to study, so that when he again finds himself afloat he may be able to do that service in zoological science which his perseverance and artistic skill would ensure.

Physiology.

The Moving Force of a Single Cilium.—An interesting experiment has been recently made by Dr. Jeffreys Wyman, of Cambridge, Mass., and repeated by Dr. Bowditch, of Boston, now in Professor Ludwig's laboratory at Leipzig, which suggests to us the above heading. If the ciliated membrane from the palate and fauces of the common frog be carefully removed and stretched on a perfectly smooth plate whilst quite fresh and moist, and on this surface a weight be placed, its surface being carefully covered with a piece of fresh peritoneum of the frog to prevent the contact of dead matter with the cilia, it will be found that the weight is slowly moved along by the force of the cilia, a weight of as much as four grammes being actually transported in this way—slowly but perceptibly. Dr. Bowditch has varied the experiment by cutting off the head of a frog and inserting a glass tube into the mouth, so that the ciliated surface may work on the rod, and he has actually succeeded in causing the head to move along the rod when in a horizontal position or but very slightly inclined against the direction of movement, simply by the ciliary power. It would be interesting to know the mechanical equivalent of a single cilium; that is to say, what fraction of a horse-power, for instance, a cilium power may be.

The Movements of Wings in Flight.—It is to Dr. J. Bell Pettigrew, F.R.S., of Edinburgh, that the credit is due of first advancing the view that during flight the movement of wings is such as to describe a figure of eight if progression of the whole body be hindered. In an elaborate investigation into the mechanism of flight in various animals, insects, birds and bats, he demonstrated that the structure was such as to provide for and necessitate this form of movement; in fact, the wing should act as a reciprocating screw. Whilst acknowledging that Dr. Pettigrew has the merit of first giving this account of the movements of flight, Dr. Marey, of Paris, the illustrious physiologist, who has so successfully applied the graphic method to the study of the circulation and of muscular contraction, has demonstrated the truth of Dr. Pettigrew's inference from structure by actual experiment. An insect's wing being gilded and a strong beam of light used, its movement could be followed by the eye; also by allowing it to brush against a cylinder covered with lamp-black, the figure of its movement was obtained. Dr. Marey is now investigating by most ingenious methods the flight of birds—with a view to determine exactly what is the effective part

of the stroke in the movement of the wing. The movement of the wing itself is recorded by an arrangement with an electric current, wires being connected with a small instrument carried on the bird's back. The impulse upwards or forwards is also recorded by means of an elastic bag containing air, on the surface of which lies a piece of lead: when a sudden movement occurs at right angles to the plane of the lead plate, it compresses the air in the bag by its inertia, and this movement is recorded by means of a tube, another bag and a lever, as in the cardiograph.

Peregrinations of Cells in the Living Body.—The study of living tissues to which Cohnheim's views on inflammation (*viz.* that there is no multiplication of the cells of connective tissue, but that pus cells are extravasated white blood corpuscles) have given rise, progresses very rapidly in Germany under the hands of Von Recklinghausen of Wurzburg, of Stricker of Vienna, of Rollet of Gratz, and their pupils. It appears certain now that both white and red blood corpuscles do freely pass through the capillary walls in inflammation; but it is equally certain, from the admirable researches of Stricker, that cells multiply in inflammation which are *not* white blood cells, such as the stellate cells of the cornea, the corneal epithelium, the connective-tissue cells of the tongue, and others which Stricker has seen under his eyes commence and finish the act of division. Among the most remarkable results recently obtained from this study of living cells is the observation of Saviotti, that cells pass *into* the capillaries and small veins as well as *out of* them. He has seen this frequently occur with the pigment cells of the frog's web, when inflammation was set up by dilute sulphuric acid, and the fact was recently witnessed also in the laboratory of Professor Stricker, of Vienna. The pigment-cells deliberately advance to the capillary wall, and passing through it are carried along in the circulation. These facts as to living cells are so remarkable that some have been inclined to suppose there is optical illusion. They are, however, now placed beyond doubt by repeated observation. Movements of cells in the tissues may now be demonstrated in many parts as well as the cornea, in the frog's egg of the second day, in the brain, in the fœtal liver, in the skin (migrated cells of Besiadecki); and hence Kölliker's supposition that all cells at one time or other can exhibit active movement is likely to be established. Recklinghausen has kept an excised frog's cornea alive for six weeks by supplying it with fresh serum and attending to cleanliness; a wonderful proof of independent vitality.

Physiology in Trinity College, Cambridge.—Trinity has lately proved her claim to stand alone and at the head of the colleges in Cambridge by the establishment of a prælectorship in pure physiology, to which that able teacher, Dr. Michael Foster, of University College, London, and Fullerian Professor in the Royal Institution, has

been called. It is a peculiar source of gratification to Dr. Foster's friends that he is able to accept this chair, since at the beginning of the year family bereavements and the threatening of serious illness held out but a gloomy prospect for future work. Dr. Foster is now in good health and will enter on his duties at Cambridge in October. When we remember that on former occasions as well as quite recently, Trinity has expressed her willingness to make some of her collegiate property available for the endowment of Professorships in the University in natural sciences, and that her generous intentions have been baulked by the ignorant parsimony of certain of the smaller colleges, we cannot but congratulate her upon having taken this step. It goes far to confirm the enumeration of Universities once given by a Trinity man, *viz.* "Dublin, Oxford, Cambridge, and Trinity College." We hope the college will provide Dr. Foster with a *large* laboratory.

Laboratories in Amsterdam and London.—Professor Kuhne has recently delivered an admirable discourse on the importance of physiological research on the occasion of the opening of the grand physiological laboratory which the city of Amsterdam has built for him. This laboratory and that of Professor Ludwig at Leipzig are the most perfect in Europe, though there are many others coming near to them. Ludwig's laboratory is as extensive as the whole of the Cambridge and Oxford laboratories taken together. There is not even one physiological laboratory in England, though we may hope to see one, at University College, as a memorial to Dr. Sharpey. King's College recently refused to build one, though Dr. Beale offered to assist in the expense in a most generous way. A strong attempt is being made to get something in the form of a laboratory put up at the public expense through the Privy Council. Let us be thankful for any such movement.

Quarterly List of Publications received for Review.*

1. Researches on Diamagnetism and Magne-crystallic Action; including the question of Diamagnetic Polarity. By John Tyndall, LL.D., F.R.S., &c. *Longmans, Green, & Co.*
2. Notes of a Course of Nine Lectures on Light, delivered at the Royal Institution of Great Britain. By John Tyndall, LL.D., F.R.S. *Longmans, Green, & Co.*
3. Other Worlds than Ours: the Plurality of Worlds studied under the light of recent scientific researches. *With Illustrations.* By Richard A. Proctor, F.R.A.S. *Longmans, Green, & Co.*
4. Alpine Flowers for English Gardens. By Wm. Robinson, F.L.S. *With Illustrations.* *John Murray.*
5. Forms of Animal Life, being Outlines of Zoological Classification based upon Anatomical Investigation, and Illustrated by Descriptions of Specimens and of Figures. By George Rolleston, D.M., F.R.S., &c. *Oxford: Clarendon Press.*
6. Strong Drink and Tobacco Smoke: the Structure, Growth, and Uses of Malt, Hops, Yeast, and Tobacco. *With 167 original Illustrations, drawn and engraved on Steel.* By Henry P. Prescott, F.L.S. *Macmillan & Co.*
7. A Handbook of Phrenology. By C. Donovan, Ph.D., &c. *With Illustrations.* *Longmans, Green, & Co.*
8. Contributions to the Theory of Natural Selection. A Series of Essays by Alfred Russel Wallace, F.R.G.S., &c. *Macmillan & Co.*
9. The Ornithosauria: an Elementary Study of the Bones of Pterodactyles, made from Fossil Remains found in the Cambridge Upper Greensand. By Harry Govier Seeley. *With 12 Plates.* *Cambridge: Deighton, Bell, & Co. London: Bell & Daldy.*
10. A Manual of Zoology for the Use of Students; with a General Introduction to the Principles of Zoology. By Henry Alleyne Nicholson, M.D., D.Sc., &c. Vol. I.: Invertebrate Animals. *R. Hardwicke.*
11. L'Uomo e la Natura. Ossia la Superficie terrestre Modificata per Opera dell Uomo. Di Giorgio P. Marsh. *Firenze: G. Barbera.*

*** We cannot undertake to acknowledge books and pamphlets on purely theological subjects, nor such as concern betting transactions.**

12. Burton-on-Trent; its History, its Water, and its Breweries. By William Molyneux, F.A.S. *Trübner & Co.*
13. The Fuel of the Sun. By W. Matthieu Williams, F.C.S. *Simpkin, Marshall, & Co.*
14. Burton and its Bitter Beer. By J. S. Bushnan, M.D. *William S. Orr & Co.*
15. A Star Atlas for the Library, the School, and the Observatory, &c. *With Two Index Plates with Coloured Constellation Figures.* Drawn by Richard A. Proctor, B.A., F.R.A.S., &c., &c. *Longmans & Co.*
16. On the Manufacture of Beet-root Sugar in England and Ireland. By William Crookes, F.R.S., &c. *Longmans & Co.*

PAMPHLETS AND PERIODICALS.

On the Thermal Resistance of Liquids. By Fredk. Guthrie.

On Ocean Currents. By James Croll.

Records of the Geological Survey of India.

Notes of Fifteen Lectures (to Women) on Physics. Delivered by Professor Guthrie at South Kensington Museum.

Descriptive Catalogue of One Hundred Microscopic Objects. Exhibited at the Royal Microscopical Society by C. Stewart, F.L.S.

Notes on Diatomaceæ. By Professor A. M. Edwards. (Boston, U.S.A., Natural History Society.)

Report presented to the Minister for Agriculture, &c., respecting the Vaccinations performed in France in 1865 and 1867. Translated by George S. Gibbs.

Report on the Present State and Condition of Pre-historic Remains in the Channel Islands. By Lieut. S. P. Oliver, R.A., &c.

What Shall we Teach? or, Physiology in Schools. By Edwin Lankester, M.D., F.R.S. *Groombridge & Sons.*

Biographical Sketch of the late Fredk. Penny, Ph.D., &c., Glasgow. By James Adam, M.D.

The Currency Question. By Rigby Wason.

Report on the Agriculture of Belgium. By Dr. Augustus Voelcker and H. M. Jenkins, F.G.S. (Reporter).

An Irish Farmer on the Land Difficulty. By J. E. Scriven.

On the Relative Safety of the Different Methods of Working Coal. By Mr. George Fowler.

Stanford's Geological Map of London.

A Guide to the Study of Insects. By A. S. Packard, jun., M.D. *Salem, Mass. London: Trübner & Co.*

Notes on a Trip to the Nicobar and Andaman Islands. By V. Ball. (Bengal Asiatic Society.)

Life and the Equivalence of Force. By J. Drysdale, M.D.
London: Turner, 77, Fleet Street. Liverpool: Holden.
Announcement of the Forthcoming Series of Annual International Exhibitions. *Science and Art Dept.*
The Gardener's Magazine.
Journal of Applied Chemistry. *New York, &c.*
The American Naturalist. *Salem, Mass.*
The Canadian Naturalist, and Proceedings of the Natural History Society of Montreal. *Montreal: Dawson Bros.*
Revue Bibliographique Universelle.
The Geological Magazine. *Trübner.*
The Food Journal. *Johns & Sons, Castle Court, Holborn.*
The Popular Science Review. *R. Hardwicke.*
Scientific Opinion. 75, *Great Queen Street, London.*
The Westminster Review. *Trübner.*
Fraser's Magazine. *Longmans.*
Longmans' Notes on Books.
Williams and Norgate's Foreign Book Circular.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar.
Stockholm: Norstedt & Söner.
The Thirty-seventh Annual Report of the Royal Cornwall Polytechnic Society. 1869.
Proceedings and Transactions of the Nova Scotian Institute of Halifax, Nova Scotia. *London: Reeves & Turner, 196, Strand.*
First Annual Report of the American Museum of Natural History.
New York.
The Journal of the Historical and Archæological Association of Ireland. *Dublin: McGlashan.*
Transactions of the Geological Society, Glasgow.
Proceedings of the Bath Natural History Society and Antiquarian Field Club. *Bath: Chronicle Office.*
Proceedings of the Royal Institution of Great Britain.
" " Royal Society.
" " Royal Astronomical Society.

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